CHAPTER 1

DELAWARE'S WILDLIFE SPECIES OF GREATEST CONSERVATION NEED

Contents


Photo: Shannon Alexander

Tables

Figures

Delaware's Animal Biodiversity

Delaware is home to thousands of animal species, ranging from microscopic marine plankton to great white sharks, and from miniscule land insects to large, familiar mammals and birds like white-tailed deer and wild turkey. The overall number of species that occur in the state remains uncertain, since so few of the invertebrate groups have been well surveyed.

The functional roles played by Delaware's wildlife species are also highly diverse, including groups with such critical roles as pollinators, insectivorous predators, decomposers of wood and plant matter, filter feeders that remove nutrients from water, and foundation species that create structured habitats used by numerous other species. Biodiversity is critical to maintaining ecosystem function (Hooper et al. 2005).

Analysis of functional diversity often provides insights into ecosystem health that are not available from examination of species diversity alone (Cadotte et al. 2011). Protecting functional diversity should be an important goal of statewide conservation planning, especially since some studies have suggested that this type of diversity may be underrepresented in protected areas (Devictor et al. 2010).

Another critical component of Delaware's wildlife diversity is beta diversity, the change in species composition between places. Impacts of stressors can result in either decreases (homogenization) (Vellend et al. 2007) or increases (Hawkins et al. 2014) in beta diversity in a given area. Tracking these patterns in beta diversity and incorporating them into conservation planning along with changes in species and functional diversity is needed in order to adequately conserve Delaware's wildlife diversity in the long term.

Regional Context

The Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC), of the Northeast Association of Fish and Wildlife Agencies (NEAFWA), has identified regional species of greatest conservation need (RSGCN, Appendix 1c). A total of 1,260 species of seven major taxonomic groups (mammals, birds, reptiles, amphibians, fish, tiger beetles, and freshwater mussels) were evaluated by the NEFWDTC. Of these, almost 30% (367 species) were identified as RSGCN based on a species' conservation status and listing in State Wildlife Action Plans (WAPs), as well as the percentage of the species' United States (U.S.) range that occurs in the Northeast (see Table 1-1 for a breakdown of RSGCN by major taxonomic groups). The invertebrate list is incomplete and in progress. The RSGCN process is ongoing and continues to evaluate additional taxa. Only two major invertebrate groups (freshwater mussels and tiger beetles) are reviewed through the RSGCN process and included in this analysis. Interestingly, the development of the RSGCN list supports earlier findings that a significant percentage of the wildlife species in the Northeast are in urgent need of dedicated conservation attention, with Stein et al. (2000) and The Heinz Center for Science Economics and Environment (The Heinz Center 2002; 2008) suggesting that approximately 33% of animal species in the U.S. are at elevated risk for extinction.

The list of all northeastern WAP's SGCN (compiled by Whitlock 2006) included 87 mammals, 263 birds, 65 reptiles, 73 amphibians, 299 fish, 27 tiger beetles, and 101 freshwater mussel species and subspecies. These numbers represent a significant percentage of the total numbers of northeastern species in all seven of these taxonomic groups (Table 1-1). The large number of species included in these lists reflects the magnitude of the threats facing fish and wildlife species in the Northeast, as well as the commendable efforts of the individual northeastern states to ensure that their WAPs were comprehensive in their coverage of species in major taxonomic groups.

Major taxonomic groups with the highest percentage of RSGCN in the Northeast include amphibians (40%), reptiles (39%), and tiger beetles (39%) (Table 1-1). Threats to amphibians and reptiles from disease, water quality impairment, and habitat loss are well known and are discussed further in this document. Some tiger beetles are associated with early successional habitats or areas such as beaches that are prone to human disturbance, and thus are at elevated risk from human activities (Knisley and Schultz 1997). Of the 356 RSGCN analyzed in Table 1-1 (analysis excludes the 11 additional federally listed invertebrates not evaluated through the RSGCN process), approximately 16% are considered to be of high regional responsibility (meaning that they are found in 50% or more of the northeastern states) and high regional concern (based on the best available information about population status and trends and inclusion in northeastern states'

WAPs). Tiger beetles have the highest percentage of species ranked high in both regional responsibility and high regional concern (21%). The next closest group, reptiles, had 8% of species in this category. Additionally, almost 30% of the RSGCN are listed under the Federal Endangered Species Act (ESA) as endangered, threatened or candidate species for listing). Mammals had the highest percentage of species with federal listing status, with 27% of the total number of species occurring in the Northeast.

For vertebrates, the percentage of species identified as SGCN in one or more of the northeastern WAPs approaches 70% of the total number of vertebrate species that occur in the Northeast (Table 1-2). The percentages of tiger beetles and freshwater mussels that were identified as SGCN by one or more of the northeastern states are even higher. For tiger beetles, 27 of the 28 species that occur in the northeastern states were identified as SGCN in one or more of the original Comprehensive Wildlife Conservation Strategies (CWCSs) for the northeastern states. For freshwater mussels, 101 of the 111 northeastern species were listed as SGCN by one or more of the northeastern states in the original CWCSs.

Table 1. 1 Regional Species of Greatest Conservation Need: Summary Statistics

Taxonomic Group	Number of Species in Region[1]	Number of Species that are State SGCN[2]	Percent of Species that are State SGCN	Number of RSGCN[3]	Percent of species that are RSGCN	Number of High Responsibility, High Concern Species[3]	Percent of High Responsibility, High Concern Species	Number of Species with Federal Status[3]	Percent of Species with Federal Status
Mammals	128	87	68%	45	35%	8	6%	34	27%
Birds	387	263	68%	110	28%	12	3%	34	9%
Reptiles	74	65	88%	29	39%	6	8%	11	15%
Amphibians	91	73	80%	36	40%	3	3%	4	4%
Fish	441	299	68%	101	23%	16	4%	11	2%
Tiger Beetles	28	27	96%	11	39%	6	21%	2	7%
Freshwater Mussels	111	101	91%	23	21%	7	6%	4	4%
Federally-listed Insects	11								

Sources: NatureServe and NALCC

[1]From NEPARC website and the comprehensive lists of vertebrate species, tiger beetles, and freshwater mussels on the NatureServe Explorer website.

[2]From Whitlock (2006) comprehensive list of SGCN for all northeastern states

See Appendix 1.4 for a list of RSGCN

[3] From most recent version of RSGCN list, produced by NEFWDTC and partners

State of Knowledge of Delaware's Species

Delaware's fish and wildlife species and their natural history have been treated extensively in the published literature. Some important monographic resources including extensive treatments of Delaware species are: *Living Resources of the Delaware Estuary* (Dove et al. 1995), *Delaware's Fresh and Brackish Water Fishes* (Raasch 1997), *The Birds of Delaware* (Hess et al. 2000), *Reptiles and Amphibians of the Delmarva Peninsula* (White and White 2007), and *Ecology of Estuarine Fishes: Temperate Waters of the Western North Atlantic* (Able and Fahay 2010).

Delaware DNREC programs, especially the Division of Fish and Wildlife's Species Conservation & Research Program (SCRP), conduct inventories, monitoring and research to guide the preservation, conservation and management of the state's flora and fauna. These reports, as well as publications produced by academia and industry, contain extremely important, but often difficult to locate, sources of species distribution data (Boakes et al. 2010). Delaware has a significant volume of this kind of species information (often referred to as grey literature), in part due to the large number of studies produced in response to industrial development of Delaware's Coastal Zone since the 1960s. Much of this grey literature has been foundational for wildlife studies in Delaware, e.g. Wang and Kernehan (1979).

Museums are also extremely important sources of species information, especially for historical occurrence data. Repositories at the University of Delaware, Delaware Museum of Natural History, American Museum of Natural History, and National Museum of Natural History (Smithsonian) are of particular significance to the knowledge of Delaware's fish and wildlife.

Data Needs Species

A pervasive problem in biodiversity conservation is a lack of capacity for species identification and research resulting in a lack of biological knowledge of many species. Often, these poorly-known species are of conservation concern. For example, Bland et al. (2014) found that as many as 64% of terrestrial mammals considered by IUCN to be "Data Deficient" may be at risk of extinction.

To address this issue, the expert review process for identifying and ranking Species of Greatest Conservation Need (SGCN) classified species as *High*, *Medium*, or *Low* Knowledge based on the amount of available information on their ecology, habitat relationships, life history, and conservation status. Species classified as *Low* Knowledge are considered Data Needs species and are listed in Appendix 1.D.

Mammals

Mammal Diversity of Delaware

Forty-five species of mammals have been designated as RSGCN in the Northeast based on their current conservation status, the percentage of their overall distribution occurring within the region, the number of states that listed them as SGCN in their 2005 CWCSs, and in response to emerging issues and threats. Seven mammal species are considered to be of "high" or "very high" concern and were listed in a majority of northeastern WAPs.

The Delaware DNREC Division of Fish and Wildlife (DNREC DFW) monitors the abundance and distribution of several mammal populations in the state. Species that are hunted and trapped, including coyote, beaver, and white-tailed deer, are monitored through DNREC DFW management programs. These programs establish annual hunting and trapping seasons, bag limits, and access restrictions through permits. Data on harvest of hunted and trapped species are collected annually. In areas where a species has become overabundant, DNREC DFW coordinates with local communities to control populations and respond to nuisance complaints as needed.

Delaware SGCN Mammals

Moles and Shrews	
Condylura cristata	Star-nosed Mole
Cryptotis parva	North American Least Shrew
Sorex fontinalis	Maryland Shrew
Other Mammals	
Lynx rufus	Bobcat
Mustela frenata	Long-tailed Weasel
Neovison vison	Mink
Sciurus niger cinereus	Delmarva Fox Squirrel

Carnivores

Carnivore guilds in eastern North America are taxonomically and functionally depleted when compared to the 17th and early 18th centuries, and even more so when compared with the Late Pleistocene (Dalerum et al. 2009). Ecologically functional populations of apex carnivores provide critical ecosystem services including herbivore and mesopredator suppression via trophic cascades. In Delaware, the native apex carnivores were likely one or more species of wolves (*Canis* sp.), the eastern cougar (*Puma concolor couguar*), and to a lesser extent, the black bear (*Ursus americanus*). Both wolves and cougars were extirpated from the state in the 1700s. Recently, eastern coyotes (*Canis latrans*), a mesopredator in areas with wolf populations, have begun to colonize the state and may assume an apex predator role in the near future. Delaware is also one of the only states in the continental US without a population of bobcat (*Lynx rufus*), although this species occurs across the bay in New Jersey and suitable habitat is present, especially in southern Delaware.

Delmarva Fox Squirrel

The Delmarva fox squirrel (*Sciurus cinereus niger*), once found in mature mixed oak-pine forests throughout the Delmarva Peninsula, was listed as Endangered by the US Fish and Wildlife Service in 1967, at which time the range had been reduced to 10% of the original size. The species had been extirpated from Delaware prior to 1920 (US Fish and Wildlife Service 2012). Between 1984 and 1987, translocated populations were established at two sites in Sussex County, Delaware (Prime Hook National Wildlife Refuge and Assawoman Wildlife Area) and the Delaware Assawoman population was designated a nonessential experimental population (US Fish and Wildlife Service 1993). The Prime Hook population has persisted without supplementation, while the Assawoman population has been lost (US Fish and Wildlife Service 2012). By 2007, a new population was identified in the Nanticoke Wildlife Management Area in southwestern Sussex County. This was the first population found in Delaware since the time of listing that was not a result of a translocation (US Fish and Wildlife Service 2007).

In 2014, the Delmarva fox squirrel was proposed for delisting from protection under the Endangered Species Act, and a draft *Postdelisting Monitoring Plan* (US Fish and Wildlife Service 2014) was completed. According to this plan, DNREC DFW will continue to list the Delmarva fox squirrel on the

State list of Endangered Species as a State Endangered species. DNREC DFW prepared a Draft *Delaware Delmarva Fox Squirrel Conservation Plan* in 2014 (DNREC DFW 2014).

Small Mammals

The conservation status of many small mammals in Delaware is poorly known, and further survey work is warranted. Several species are apparently restricted to the Piedmont, but their population status there is uncertain.

Mustelids (mink and weasels) are apparently now uncommon in Delaware, but that has not always been the case. Mink (*Neovison vison*) was noted by state wildlife managers in 1942 as having been "restricted by intensive trapping to a point of extinction" in the state, with "only a very few places in Delaware where they are to be found" (Delaware Board Game and Fish Comm. 1942). The same report refers to the long-tailed weasel (*Mustela frenata*, at the time called *Mustela noveboracensis*) as "not considered scarce" in Delaware, being found in New Castle and scattered areas of Kent and Sussex counties in "open mixed forests adjoining farm communities where streams are numerous". Both of these reports suggest that mustelids have experienced significant declines in Delaware during the 20th century. Studies in the southeast suggest that environmental contaminants may play an important role in mustelid population declines, especially on the coastal plain (Osowski et al. 1995).

Rodents are also poorly known in Delaware. Increased survey efforts are needed to determine species abundance and distributions for SGCN listed here as well as other species whose conservation status is less well known.

Bats

Delaware's SGCN bats are divided into two main groupings based on life history. "Cave bats" spend their winters hibernating in caves, and often form colonies to roost and raise their young in the summer. Colonies can be found in hollow trees, or buildings and other man-made structures. "Tree bats" are generally more solitary in nature, roost under pieces of bark alone or in small groups and spend their time foraging in and near forests. All these things make tree bats difficult to study.

Table 1. 2 Delaware Bat SGCN

Cave Bats	
Eptesicus fuscus	Big Brown Bat
Myotis leibii	Eastern Small-footed Myotis
Myotis lucifugus	Little Brown Myotis
Myotis septentrionalis	Northern Myotis
Perimyotis subflavus	Eastern Pipistrelle
Tree Bats	
Lasionycteris noctivagans	Silver-haired Bat
Lasiurus borealis	Eastern Red Bat
Lasiurus cinereus	Hoary Bat
Nycticeius humeralis	Evening Bat

Fourteen species of bats are listed as northeast RSGCN. One species, the eastern small-footed myotis (*Myotis leibii*) is recognized as high responsibility and high concern throughout the Northeast. Many of the northeastern species of bats are acutely threatened by white-nose syndrome (WNS), a fungal disease that alters the torpor cycle and metabolism of overwintering bats and leads to significant mortalities. Delaware is part of a nation-wide team of state and national biologists tracking White-nose Syndrome. Bats hibernating at Fort Delaware and Fort DuPont State Parks were confirmed to have White-Nose Syndrome (WNS) in 2012 and the fungus that causes the disease was documented in bats returning to summer sites in 2010.

The northern long-eared bat (*Myotis septentrionalis*) is one of the species of bats most impacted by WNS. Due to declines caused by the disease, as well as continued spread of WNS, the northern long-eared bat was listed as Threatened under the Endangered Species Act (USFWS 2015). Delaware listed both northern long-eared bats and little brown bats as state endangered in 2014.

Delaware is collecting information on the size and location of bat maternity colonies and hibernation sites statewide, including through a volunteer "bat spotters" program. Acoustic monitoring is also conducted across Delaware in summer via acoustic transects using car-mounted detectors. Migrating bats are being studied via stationary acoustic monitoring stations and both

passive and acoustic monitoring is taking place throughout the state to document species locations and status.

Marine Mammals

Delaware's marine mamal SGCN includes 6 species of whales, as well as harbor porpoise (*Phocoena phocoena*) and hooded seal (*Cystophorus cistata*).

Table 1. 3 Delaware Marine Mammal SGCN

Marine Mammals (8)	
Balaenoptera borealis	Sei Whale
Balaenoptera musculus	Blue Whale
Balaenoptera physalus	Fin Whale
Cystophora cristata	Hooded Seal
Eubalaena glacialis	North Atlantic Right Whale
Megaptera novaeangliae	Humpback Whale
Phocoena phocoena	Harbor Porpoise
Physeter macrocephalus	Sperm Whale

Conservation of whales in the Northeast has been a significant concern since the depletion of local populations due to whaling in the mid-19th century. New potential threats include shipping activity, entanglement in fishing gear, and offshore energy development. Some northeastern whale species (e.g., Humpback, Fin) have shown signs of recovery, since a global whaling ban was imposed in 1985. In 1972 Canada stopped whaling and the U.S. passed the Marine Mammal Protection Act, which banned all taking of marine mammals or importing of marine mammal products. Right Whale populations were severely depleted in the 17th and 18th centuries. Sperm whaling increased in the 18th century, and was becoming less economically viable by the second half of the 19th century when the focus of the New England whaling industry shifted to Blue and Fin whales. Other northeastern whales, such as the North Atlantic Right Whale, have recovered much more slowly from heavy harvest pressure.

Multiple agencies have jurisdiction over the conservation of marine mammals, including state marine fisheries programs, National Oceanographic and Atmospheric Administration (NOAA) and the state wildlife agencies. Another important factor is that the range of a whale population is so large that the jurisdiction of any individual state comprises a very small proportion of that range.

Birds

Avian Diversity of Delaware

The Delaware State List of Bird Species includes 410 species that have been accepted by the Delaware Bird Records Committee (DBRC) of the Delmarva Ornithological Society (DOS). This official state list includes accidental and vagrant species as well as more regularly occurring species.

The Delmarva Ornithological Society publishes an annual journal, *The Delmarva Ornithologist* (1964-present), that contains articles related to avian research and observation conducted by members in the region. DOS also conducts an annual spring count that provides data on abundance and diversity of birds in the state during early May.

National monitoring programs have helped contribute to knowledge of Delaware's avifauna. This includes the annual Christmas Bird Count, coordinated by the National Audubon Society and compiled locally by DOS and the Sussex Bird Club. There are currently seven Christmas Bird Count circles (plots) in Delaware that provide consistent data on wintering bird populations in the state.

The North American Breeding Bird Survey (BBS) is a cooperative effort between the United States Geological Survey (USGS) and Canadian Wildlife Service. The BBS monitors the status and trends of North American bird populations by collecting data at point counts along randomly established roadside routes. There are currently ten BBS routes in Delaware spanning all three counties.

The first standardized project to document the state's breeding avifauna occurred from 1983-1987 and resulted in the *Birds of Delaware* (Hess et al. 2000), which included the results state's first breeding bird atlas. Results of this effort indicated that at the time of publication four species that historically bred in the state had been extirpated, while an additional 11 were not found breeding during the survey period. Twenty-four breeding species had estimated populations of less than 20 pairs, putting them at high risk of future extirpation. Twenty-one breeding birds and 16 migrants or winter visitors were of management concern due to having low or declining populations or being dependent on severely degraded habitat. As a whole, 93 species of Delaware birds were declining.

A 2nd Delaware Breeding Bird Atlas was conducted from 2008-2012. Publication of the results of this project are underway, and raw occurrence data are available. The Atlas found breeding evidence for 171 total species, 147 of which were confirmed in at least one block (BBA Explorer 2015).

Between the two atlas periods (1987 – 2008) the SCRP (formerly Delaware Natural Heritage Program) incorporated breeding bird surveys into routine inventory of state and federal natural

areas. The results from several surveys were published in DNREC publications and in the *Delmarva Ornithologist*.

All but one of the 21 species listed as Endangered in Delaware are known to have bred in the state. These species are listed in Table 1.2 below.

Table 1. 4 Endangered Breeding Birds of Delaware

Pied-billed Grebe	*Podilymbus podiceps*
Northern Harrier	*Circus cyaneus*
Broad-winged Hawk	*Buteo platypterus*
Black-crowned Night-heron	*Nycticorax nycticorax*
Yellow-crowned Night –Heron	*Nyctanassa violacea*
American Kestrel	*Falco sparverius*
Piping Plover	*Charadrius melodus*
Short-eared Owl	*Asio flammeus*
American Oystercatcher	*Haematopus palliates*
Black Rail	*Laterallus jamaicensis*
Upland Sandpiper	*Bartramia longicauda*
Black Skimmer	*Rhyncops niger*
Henslow's Sparrow	*Ammodramus henslowii*
Common Tern	*Sterna hirundo*
Forster's Tern	*Sterna forester*
Least Tern	*Sterna antillarum*
Cerulean Warbler	*Setophaga cerulean*
Hooded Warbler	*Setophaga citrine*
Swainson's Warbler	*Limnothlypis swainsonii*

Sedge Wren	*Cistothorus platensis*

The distributions of breeding birds were modeled for Delaware, Maryland, and New Jersey by McCorkle et al. (2006) in the Maryland, Delaware and New Jersey GAP Analysis Project, conducted by the US Fish and Wildlife Service Delaware Bay Estuary Project, the US Geological Survey, and the University of Maryland Eastern Shore. Bird SGCN with less than 1% of their predicted distributions occurring within protected natural lands (GAP Status 1 or 2) in the three state region include: American kestrel (*Falco sparverius*), short-eared owl (*Asio flammeus*), royal tern (*Sterna maxima*) and common nighthawk (*Chordeiles minor*) (McCorkle et al. 2006).

Regional, National, and International Perspectives

Regional Species of Greatest Conservation Need (RSGCN)

110 species of birds were identified as RSGCN in the Northeast. Of these, 10 species were ranked by the NEFWDTC as "very high" concern and "high" responsibility for the Northeast. Thirty-five of the 110 RSGCN birds occur along the northeastern region's coast, either in salt marshes, beaches, dunes, or offshore islands. Throughout the Northeast, these habitats have been heavily altered by long-term human activities, including development and stabilization, pollution, marsh filling and draining, pesticide spraying, and recreational use.

Audubon Important Bird Areas

Important Bird Areas, or IBAs, are sites that provide essential habitat for one or more species of bird. IBAs include sites for breeding, wintering, and/or migrating birds. IBAs may be a few acres or thousands of acres, but usually they are discrete sites that stand out from the surrounding landscape. IBAs may include public or private lands, or both, and they may be protected or unprotected.

Table 1. 5 Important Bird Areas (IBAs) in Delaware

IBA Name	IBA Priority	Acreage
White Clay Creek State Park	State	5,001
Red Clay Valley	Continental	_____
Delaware Coastal Zone	Global	270,009
Pea Patch Island	State	311
Great Cypress Swamp Conservation Area	State	12,400

Bird Conservation Regions

North American Bird Conservation Initiative (NABCI) Bird Conservation Regions (BCRs) are ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues. Started in 1999, the U.S. North American Bird Conservation Initiative (NABCI) Committee is a coalition of government agencies, private organizations, and bird initiatives in the United States working to ensure the long-term health of North America's native bird populations. Delaware's coastal plain is within BCR 30 (New England / Mid-Atlantic Coast), and the Delaware piedmont is within BCR 29 (Piedmont).

BCR 30: New England / Mid-Atlantic Coast

BCR 30 has the densest human population of any BCR in the country. Much of what was formerly cleared for agriculture is now either in forest or residential use. Coastal wetland and beach habitats support the highest priority species, including saltmarsh, Nelson's, and seaside sparrows, piping plover, American oystercatcher, American black duck, and black rail. The region includes critically

important migration sites for red knot, ruddy turnstone, sanderling, semipalmated sandpiper, and dunlin. Terns and gulls nest in large numbers and large mixed colonies of herons, egrets, and ibis occur on islands in the Delaware and Chesapeake Bay regions.

Estuarine complexes and embayments created behind barrier beaches in this region are extremely important to wintering and migrating waterfowl, including approximately 65% of the total wintering American black duck population along with large numbers of greater scaup, tundra swan, gadwall, Atlantic brant, and canvasback.

BCR 29: Piedmont

BCR 29 is transitional between the mountainous Appalachians and the flat coastal plain, and is dominated in the north by oak-hickory hardwoods. Interior wetlands, reservoirs, and riverine systems provide migration and wintering habitat for waterfowl and some shorebirds. The fragmented patchwork of pasture, woodlots, and suburban sprawl that now dominates most of this region creates significant bird conservation challenges, particularly since upland conservation is not as well funded as wetland conservation in the Joint Venture.

The Piedmont Bird Conservation Plan (Watson 2014) identifies priority species and habitats. Fifty-seven species were identified as priority, mostly associated with grasslands/early-successional habitats, forests, and forested wetlands and freshwater emergent wetlands. Primary efforts in this BCR will focus on conservation of existing forests and grasslands, particularly on private lands, and maintaining or establishing habitat corridors between priority conservation areas.

The Atlantic Coast Joint Venture

The Atlantic Coast Joint Venture (ACJV) is a partnership focused on the conservation of habitat for native birds in the Atlantic Flyway of the United States from Maine south to Puerto Rico. The ACJV includes 17 states and commonwealths and key federal and regional habitat conservation agencies and organizations in the joint venture area.

Figure 1. 1 Map of North American Bird Habitat Joint Ventures, showing the Atlantic Coast Joint Venture (ACJV) area in light blue

Regional Initiatives for Specific Groups of Birds

Regional initiatives and conservation plans for specific bird taxa are discussed within the relevant sections for each group below.

Delaware Bird Species of Greatest Conservation Need

Of the total bird diversity in the state, 183 species have been determined to be SGCN. The process of identifying SGCN is discussed at the end of this chapter and Appendix 1.A lists all SGCN. The 2015 plan employed a different prioritization process than was used in 2007, which resulted in the removal of several species and the addition of others. In general, the 2015 list includes many more species found in Delaware only as migrants or wintering birds, as well as additional pelagic species.

Waterbirds

The *North American Waterbird Conservation Plan*, a project of the Waterbird Conservation for the Americas Initiative (www.waterbirdconservation.org), assessed the abundance and distribution of 210 waterbird species in North America and found that one-third of colonial nesting waterbirds are at risk of serious population declines. Eleven pelagic seabirds are imperiled, while seven wading birds and 36 pelagic and coastal seabirds are of high conservation concern. Only 17% of 166 colonial waterbird species are exhibiting apparent or biologically significant population increases, while another 15% of these species are lacking information to estimate population trends (Kushlan et al. 2002).

The Mid-Atlantic/New England Maritime Regional Working Group for Waterbirds (MANEM) is a regional partnership working to conserve waterbirds in the Northeast. The MANEM Waterbird Conservation Plan is being implemented within the context and framework of the North American Waterbird Conservation Plan. 32% of waterbirds occurring in the MANEM region are declining at the continental scale, with Audubon's shearwater, black rail, and king rail experiencing the greatest declines (MANEM Waterbird Working Group 2006).

Migratory Shorebirds

Table 1. 6 Delaware Migratory Shorebird SGCN

Migratory Shorebirds (19)	
Arenaria interpres	Ruddy Turnstone

Calidris alba	Sanderling
Calidris alpina	Dunlin
Calidris canutus	Red Knot
Calidris fuscicollis	White-rumped Sandpiper
Calidris melanotos	Pectoral Sandpiper
Calidris pusilla	Semipalmated Sandpiper
Limnodromus griseus	Short-billed Dowitcher
Limosa fedoa	Marbled Godwit
Limosa haemastica	Hudsonian Godwit
Numenius phaeopus	Whimbrel
Phalaropus tricolor	Wilson's Phalarope
Pluvialis dominica	American Golden-Plover
Pluvialis squatarola	Black-bellied Plover
Recurvirostra americana	American Avocet
Tringa flavipes	Lesser Yellowlegs
Tringa melanoleuca	Greater Yellowlegs
Tringa solitaria	Solitary Sandpiper
Tryngites subruficollis	Buff-breasted Sandpiper

Delaware is positioned in the Atlantic flyway. Habitat along the Delaware bayshore serves as a critical stopover site for waterfowl and shorebirds. This includes the federally threatened Red Knot, whose entire population relies on the Delaware Bay as a spring stopover site. The matrix of protected marshes and impoundments are utilized by thousands of shorebirds and waterfowl during spring and fall migration.

The Delaware Bay hosts one of the largest concentrations of migrating shorebirds in the Western Hemisphere (Senner and Howe 1984, Myers et al. 1987). Delaware Bay is the most important spring stopover site for Semipalmated Sandpiper (*Calidris pusilla*), Ruddy Turnstone (*Arenaria interpres*), Sanderling (*Calidris alba*), and Red Knot (*Calidris rufa*). The *rufa* subspecies of Red Knot has been the subject of regional conservation measures and has recently been listed as threatened under the ESA (USFWS 2014). In Delaware Bay, tide cycles have great influence on the distribution of shorebirds in beach and marsh environments. Factors that threaten this globally important site include horseshoe crab overharvest, direct development, human disturbance, and effect of toxic accidents (Clark et al. 1993).

In 1974, Manomet Bird Observatory initiated the International Shorebird Survey (ISS) which was the first attempt to survey shorebird populations by focusing on migratory stopover sites. In 1986, Delaware Bay became the first Western Hemisphere Shorebird Reserve Network (WHSRN) Site of Hemispheric Importance for migrating shorebirds.

There is limited information on population sizes and trends for most species of shorebirds in North America, but the available information suggests that 46% of the 72 species in North America are declining. Population trend estimates are uncertain for another 53% of the species; and only two species have populations that are apparently increasing (Brown et al. 2001). Recognition of the need for more systematic surveys of shorebirds to effectively track populations led to the development of the *United States Shorebird Conservation Plan* and the Program for Regional and International Shorebird Monitoring (PRISM). These efforts are designed to estimate breeding population sizes and trends, spatial distribution and abundance at stopover sites, and to assess habitat use patterns for 72 species of shorebirds nesting in North America (Bart et al. 2002). More importantly, results from this research can be used to develop effective conservation strategies and action plans to help stabilize shorebird populations.

The Northern Atlantic Regional Shorebird Plan (Clark and Niles 2001) was produced at the regional level from the U.S. Shorebird Conservation Plan, developed with the purpose of creating conservation goals, identifying critical habitat, and promoting education and outreach programs to facilitate shorebird conservation. Several shorebird plans have also been developed that provide species-specific conservation actions including those for the American Oystercatcher (Schulte et al. 2007) and Red Knot (Niles et al. 2010).

The DNREC Division of Fish and Wildlife runs the Delaware Shorebird Project that works to mitigate the threat to the state's shorebirds. Since 1997, the project team has conducted research and monitoring on populations and health of migratory shorebirds while coordinating with an international network that directs shorebird habitat protection and management plans.

Even though coastal habitats are regulated by the Coastal Resources Management Council (CRMC), dredging projects, development, human disturbance, and more recently, rising sea levels threaten prime shorebird habitat. Delaware shorebirds need protection, as do the few remaining coastal habitats that can support them.

The Atlantic Flyway Shorebird Conservation Business Strategy defines focal species of shorebirds along with strategies and specific objectives for their conservation. The Strategy involves numerous federal, state, provincial, and local governments, conservation groups, universities and individuals.

Beach-nesting Birds

Table 1. 7 Delaware Beach-nesting Bird SGCN

Beach-nesting Birds (5)	
Charadrius melodus	Piping Plover
Haematopus palliatus	American Oystercatcher
Rynchops niger	Black Skimmer
Sterna hirundo	Common Tern
Sternula antillarum	Least Tern

Annual surveys are presently conducted by DNREC Division of Fish and Wildlife for colonial nesting birds (e.g., egrets, gulls, terns) and piping plover. Piping plover, which was listed as threatened under the federal Endangered Species Act (ESA) in 1986, has been managed by DNREC since 1990 under a binding agreement between DNREC and the USFWS and subsequent species management plan. Piping plover nesting areas at Cape Henlopen State Park are closed annually to the public to protect the birds from disturbance during their March to September nesting season. The closure, which must include feeding habitat as well as nesting areas, has been successful, increasing the number of piping plover nesting pairs from a low of two pairs to a high of nine pairs.

Beach and dune habitats of Delaware also support several other specialist species, including Least Tern (*Sterna antillarum*), Common Tern (*Sterna hirundo*), American oystercatcher (*Haematopus palliatus*) and Black Skimmer (*Rhyncops niger*). As with the Piping Plover, remaining populations of these species depend heavily upon active protection and management. Least terns typically nest in scrapes in sand with shells or pebbles and occasionally in construction sites or on flat rooftops.

In 2001, the American oystercatcher was identified in the U.S. Shorebird Conservation Plan (Brown et al. 2001) as a species warranting special attention because of its small and declining population. As a result, the American Oystercatcher Working Group was formed to devise and implement a regional research, monitoring, and conservation strategy for the oystercatcher along the Atlantic and (to a lesser extent) Gulf Coasts of the United States. This working group, along with the National Fish and Wildlife Foundation (NFWF) produced the American Oystercatcher Business Plan in 2008. Under the plan, Delaware is a Tier 2 state, due to its relatively small numbers of oystercatchers.

Colonial Waterbirds

Table 1. 8 Delaware Colonial Waterbird SGCN

Colonial Waterbirds – Cormorants	
Phalacrocorax auritus	Double-crested Cormorant
Colonial Waterbirds – Pelicans	
Pelecanus occidentalis	Brown Pelican
Colonial Waterbirds – Herons	
Ardea alba	Great Egret
Ardea herodias	Great Blue Heron
Bubulcus ibis	Cattle Egret
Egretta caerulea	Little Blue Heron
Egretta thula	Snowy Egret
Egretta tricolor	Tricolored Heron
Nyctanassa violacea	Yellow-crowned Night-Heron
Nycticorax nycticorax	Black-crowned Night-Heron
Plegadis falcinellus	Glossy Ibis

Colonial Waterbirds - Saltmarsh Nesting	
Larus argentatus	Herring Gull
Larus marinus	Great Black-backed Gull
Leucophaeus atricilla	Laughing Gull
Sterna forsteri	Forster's Tern
Colonial Waterbirds – Non-breeding Terns	
Chlidonias niger	Black Tern
Gelochelidon nilotica	Gull-billed Tern
Sterna dougallii	Roseate Tern
Thalasseus sandvicensis	Sandwich Tern

Saltmarsh Nesting Colonial Waterbirds

Three species of saltmarsh-nesting gulls and terns have historically nested on the marsh islands of Rehoboth Bay, while a fourth, the great black-backed gull, began to expand its breeding range southward into Delaware in the late 1980s. The expansion of large and aggressive *Larus marinus* into Inland Bays colonies may have potential negative effects on the other species in this group, as was the case in mixed species colonies in Maine (Ellis and Good 2006).

Colonial saltmarsh birds nest on the ground or in low vegetation of the marsh platform and are sensitive to disturbance and predation, especially by mammals. Primary conservation activities for these species include consistent monitoring and efforts to reduce disturbance. Foraging habitats, usually salt marshes, adjacent to nesting sites, are also important habitat components that will be threatened by rising sea levels.

Herons

One mile northeast of Delaware City, the 310-acre Pea Patch Island hosts a nationally significant breeding colony for nine species of herons and ibis. Pea Patch Island is an ideal nesting ground for

these birds because of the types and arrangement of trees on the island, and its proximity to the rich food sources in the coastal marshes and agricultural areas of Delaware and New Jersey. On the island, both mixed hardwoods and the *Phragmites* marsh are utilized for nesting, depending on the species. This colony is the only known breeding location in the state for little blue heron and cattle egret, and the largest heron rookery on the Atlantic coast north of Florida.

While some of the nine species may be found nesting in other, smaller rookeries throughout the region, Pea Patch Island is the only site known to support all of these species. The species nesting at Pea Patch include the great blue heron (*Ardea herodias*), great egret (*Ardea alba*), snowy egret (*Egretta thula*), little blue heron (*Egretta caerulea*), cattle egret (*Bubulcus ibis*) black-crowned night-heron (*Nycticorax nycticorax*), tricolored heron (*Egretta tricolor*), yellow-crowned night-heron (*Nyctanassa violaceus*) and glossy ibis (*Plegadis falcinellus*).

In 1993 the heronry hosted 12,000 pairs of nesting herons. The island's location also posed some significant issues for the health of the heron nesting colony: among them, rapidly expanding suburban development and changes to habitat quality, agricultural pesticides and industrial contaminants, human disturbance and oil spills and other industrial accidents. Researchers in the 1990's noticed issues with heron health (including lesions and low nestling survival) and had documented declines in the numbers of nesting birds (around 6,000 pairs by 1997). Because of its interconnectedness with the river and surrounding areas, a single cause of the declining health of the colony could not be identified.

The Pea Patch Island Heronry Region Special Area Management Plan was developed as a way to address the diverse range and complex nature of the issues affecting the health of the Pea Patch Island Heronry and its surrounding habitats. The development of this plan involved stakeholders from state, local and federal government agencies, universities, industry, citizens and not-for profit organizations. Participants in the planning process developed 28 strategies through a consensus building process. These strategies were finalized in the 1998 Pea Patch Island Heronry Region Special Area Management Plan. An Implementation team was formed when the planning process was complete; their job was to coordinate with each other, prioritize strategies and find resources to implement the actions outlined within the strategies. By June of 2001, 21 of the 28 strategies had been implemented. Projects conducted as part of the Pea Patch Island Heronry Region Special Area Management Plan are outlined in the 2001 Progress Report.

Today, the Pea Patch Island Heronry continues to be an active and important regional heron nesting colony, but populations of nesting birds remain significantly lower than the 12,000 pairs documented in 1993. Nevertheless, the diversity of species continues to make Pea Patch Island one

of the most unique and important bird nesting areas on the East Coast. The DNREC Division of Parks and Recreation continues to manage Pea Patch Island Heronry as a Nature Preserve and entry to the area is prohibited. DNREC Parks and Recreation conducts monthly flight surveys, with the assistance of volunteers, during the nesting season to monitor and track population numbers.

Waterfowl

Table 1. 9 Delaware Waterfowl SGCN

Bay Waterfowl	
Aythya affinis	Lesser Scaup
Aythya Americana	Redhead
Aythya marila	Greater Scaup
Aythya valisineria	Canvasback
Branta bernicla	Brant
Bucephala albeola	Bufflehead
Bucephala clangula	Common Goldeneye
Oxyura jamaicensis	Ruddy Duck
Marine Waterfowl	
Clangula hyemalis	Long-tailed Duck
Melanitta americana	American Scoter
Melanitta fusca	White-winged Scoter
Melanitta perspicillata	Surf Scoter
Somateria mollissima	Common Eider
Freshwater Waterfowl	
Anas acuta	Northern Pintail
Anas Americana	American Wigeon

Anas discors	Blue-winged Teal
Anas platyrhynchos	Mallard
Branta canadensis	Canada Goose (Atlantic migratory population only)
Cygnus columbianus	Tundra Swan
Lophodytes cucullatus	Hooded Merganser

The United States Fish and Wildlife Service (USFWS) Waterfowl Population Status Report (USFWS 2014) includes the most current breeding population and production information available for waterfowl in North America and is a result of cooperative efforts by the U.S. Fish and Wildlife Service (USFWS), the Canadian Wildlife Service (CWS), various state and provincial conservation agencies, and private conservation organizations.

The North American Waterfowl Management Plan, first published in 1986, and most recently updated in 2012 (CITE), aims to protect continental habitat conditions that could sustain and improve waterfowl populations. The Plan calls for the protection of North America's remaining wetlands and restoration of waterfowl populations through habitat protection, restoration, and enhancement activities.

The Atlantic Coast Joint Venture (ACJV), a partnership of government agencies and conservation partners, has designated two Waterfowl Focus Areas in Delaware: the Delaware Bay Partnership (New Jersey, Pennsylvania and Delaware) and the Chesapeake Bay Waterfowl Working Group (Maryland, Delaware, Virginia and West Virginia)

Species-specific efforts are being conducted, including the the Black Duck Joint Venture and the Atlantic Brant Management Plan (2002) .

Marine Waterfowl

These five species regularly occur in varying numbers off the Atlantic Coast of Delaware during migration and winter. In recent years a periodic seawatch has been conducted by the Delmarva Ornithological Society and Sussex Bird Club to help assess abundance of these and other species during migration.

The Sea Duck Joint Venture is a conservation partnership under the North American Waterfowl Management plan. Their goal is increase knowledge and management of sea ducks so as to more effectively manage them. This project is a large-scale, multi-year, multi-partner satellite tracking program for sea ducks along the Atlantic coast and Great Lakes, with the following primary objectives:

- Fully describe the annual migration patterns for four species of sea ducks (surf scoter, black scoter, white-winged scoter, long-tailed duck) in the Atlantic flyway and Great Lakes by 2014.
- Map local movements and estimate length-of-stay during winter for individual radio-marked ducks in areas proposed for placement of wind turbines
- Identify near-shore and offshore habitats of high significance to sea ducks to help inform habitat conservation efforts.
- Estimate rates of annual site fidelity to wintering areas, breeding areas, and molting areas for all four focal species in the Atlantic flyway.

Freshwater Waterfowl

Delaware Division of Fish and Wildlife has conducted annual aerial waterfowl surveys throughout the state since 1974. These surveys help measure long-term trends in duck and goose populations. Flights are usually made in mid-October, mid-November, mid-December and the second week in January. The January flight is part of the Midwinter Waterfowl Survey, a coast-wide effort to survey waterfowl throughout the Atlantic Flyway at approximately the same time. The state surveys cover the primary waterfowl habitat in Delaware, approximately the eastern half of the state, and are divided into 11 zones. Data are available at http://www.dnrec.delaware.gov/fw/Hunting/Pages/Waterfowl Surveys.aspx

Ducks Unlimited (DU) is a national conservation organization with a significant presence in Delaware. DU's Delaware conservation program has restored, enhanced, or conserved 15,497 acres of wetlands and adjacent habitat. The goal of these projects has been to maximize quality and quantity of habitat for migratory and wintering waterfowl.

Several species of breeding freshwater ducks in Delaware, including gadwall and blue-winged teal, have experienced apparent declines in breeding evidence in the state based on comparison of data from the first to second atlas periods (DNREC DFW unpublished data).

Marine and Pelagic Birds

Table 1. 10 Delaware Pelagic Bird SGCN

Pelagic Birds	
Morus bassanus	Northern Gannet
Oceanodroma castro	Band-rumped Storm-Petrel
Onychoprion anaethetus	Bridled Tern
Pelagodroma marina	White-faced Storm-Petrel
Phalaropus lobatus	Red-necked Phalarope
Puffinus gravis	Great Shearwater
Puffinus griseus	Sooty Shearwater
Puffinus lherminieri	Audubon's Shearwater
Stercorarius longicaudus	Long-tailed Jaeger
Sterna paradisaea	Arctic Tern
Uria lomvia	Thick-billed Murre

Pelagic birds are difficult to assess as they do not nest in state waters and because local populations vary temporally and spatially. However, such species are still at risk from a variety of threats, including loss of habitat or mortality from offshore wind turbines and oil spills, and as bycatch in fishing gear.

The offshore waters of Delaware are part of Pelagic Bird Conservation Region (PBCR) 78 (Northeast US Continental Shelf)

Not nearly enough is known about Atlantic seabirds and their vulnerability to a number of current and emerging threats while in their primary offshore habitats. Data on their pelagic distribution and abundance are critical for monitoring population trends, understanding their basic ecology and role in marine ecosystems, assessing actual or potential impacts from oil spills, fisheries bycatch, and offshore development (shipping, wind generation, gas and mineral exploration), identifying critical marine habitats, and educating the public about marine conservation issues. The Northwest Atlantic Birds at Sea Conservation Cooperative has formed and is committed to engaging resource agencies

and partners in and outside its membership to develop new alliances to prioritize and implement research, management, policy and educational actions needed to sustain marine birds in their offshore environments. A Marine Bird Mapping and Assessment project is currently being conducted by the North Atlantic Landscape Conservation Cooperative (NALCC) and mulitple partners.

Marsh Birds

Table 1. 11 Delaware Marsh Bird SGCN

Freshwater Marsh Birds	
Botaurus lentiginosus	American Bittern
Actitis macularius	Spotted Sandpiper
Gallinago delicate	Wilson's Snipe
Himantopus mexicanus	Black-necked Stilt
Ixobrychus exilis	Least Bittern
Podilymbus podiceps	Pied-billed Grebe
Porzana carolina	Sora
Rallus elegans	King Rail
Rallus limicola	Virginia Rail
Saltmarsh Birds	
Ammodramus caudacutus	Saltmarsh Sparrow
Ammodramus maritimus	Seaside Sparrow
Ammodramus nelsoni	Nelson's Sparrow
Anas rubripes	American Black Duck
Asio flammeus	Short-eared Owl
Circus cyaneus	Northern Harrier

Laterallus jamaicensis	Black Rail
Melospiza georgiana nigrescens	Coastal Plain Swamp Sparrow
Rallus longirostris	Clapper Rail
Tringa semipalmata	Willet
Tyto alba	Barn Owl
Cistothorus palustris	Marsh Wren
Cistothorus platensis	Sedge Wren

Since many marsh birds are nocturnal, survey data is limited. The publication of the North American Marsh Bird Monitoring Protocol (Conway 2009) and framework for monitoring site selection (Johnson et al. 2009) have greatly improved comparability of recent marsh bird survey data across studies and jurisdictional boundaries.

Freshwater Marsh Birds

The majority of Delaware's freshwater marsh habitat occurs within coastal impoundments that are highly threatened by sea level rise, making the outlook for these species in the state uncertain. Several SGCN species utilize these freshwater emergent marsh habitats, including american bittern (*Botaurus lentiginosus*), king rail (*Rallus elegans*), and least bittern (*Ixobrychus exilis*).

Saltmarsh Birds

Salt marshes are universally considered to be among the most important wildlife habitats in North America, and Delaware's contribution to the regional distribution and conservation of this habitat is significant. Partners in Flight (PIF) identified maritime marshes as the habitat harboring the largest number of high-priority species in the region (CITATION). The Saltmarsh Sparrow is considered by PIF to be the species of highest conservation priority in the region (Rosenberg and Dettmers 2000).

Bird species inhabiting saltmarsh are widely considered to be highly imperiled due to sea level rise. Delaware is responsible for approximately 10% of the northeastern region population of Clapper Rail (Shriver et al. 2014).

The Saltmarsh Habitat and Avian Research Program (SHARP) helps provide critical information for the long-term conservation of tidal-marsh birds. This collaborative research program focuses on monitoring the health of North America's tidal-marsh bird community in the face of sea-level rise and upland development.

Black rail populations have been declining in the eastern United States for over a century. This decline has resulted in a retraction of its breeding range, an overall reduction in the number of breeding locations within its core range, and a loss of individuals within historic strongholds. Over the past 10-20 years, some reports indicate that populations have declined 75% or greater and have become dangerously low (The Center for Conservation Biology 2014).

American black duck has experienced apparent declines in breeding evidence in the state based on comparison of data from the first to second atlas periods (DNREC DFW unpublished data).

Landbirds

While best known for its waterbird habitat, Delaware also provides critical habitat for landbirds. Important groups for which Delaware has particularly high regional responsibility include Neotropical migrant songbirds that use the state for stopover habitat, migrating and wintering raptors, breeding birds of agricultural habitats (including horned lark and grasshopper sparrow), early successional habitat breeding birds, and forest breeding birds of southern affinities that are at or near their northern range limit in Delaware.

Grassland Birds

Table 1. 12 Delaware Grassland Bird SGCN

Grassland Birds	
Ammodramus henslowii	Henslow's Sparrow
Ammodramus savannarum	Grasshopper Sparrow
Bartramia longicauda	Upland Sandpiper

Dolichonyx oryzivorus	Bobolink
Eremophila alpestris	Horned Lark
Falco sparverius	American Kestrel
Lanius ludovicianus	Loggerhead Shrike
Passerculus sandwichensis	Savannah Sparrow
Pooecetes gramineus	Vesper Sparrow
Spiza Americana	Dickcissel
Sturnella magna	Eastern Meadowlark

The *2009 State of the Birds* report concluded that grassland birds are among the fastest and most consistently declining groups of birds in North America, with 55% of species declining significantly (North American Bird Conservation Initiative 2009). According to the *Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape* (Anderson and Olivero Sheldon 2011), of the 22 bird species that preferentially breed in grasslands, fields and field edges, 17 have experienced persistent, widespread declines. This trend probably reflects the expansion of these species' habitat during the period of widespread farming and pasturing followed by agricultural abandonment and a return of the land to forest.

Just as many forest-dependent birds are area-sensitive, many grassland birds also require large, contiguous habitat patches to maintain viable breeding populations. Breeding Bird Surveys (BBS) conducted by the Biological Resource Division of USGS and volunteers throughout the United States have shown alarming declines in the number of grassland birds nationwide. For instance, bobolinks have declined by 38 percent and grasshopper sparrows by 69 percent in the past 25 years.

Grassland habitat has experienced dramatic declines in Delaware since the 1980s and there is currently very little available habitat for these species (see Chapter 2 for a detailed analysis of grassland habitats). Corresponding with loss of suitable habitat, grassland-dependent bird species have declined precipitously in distribution in the state. Eastern meadowlark was found in only 30% blocks in the 2nd DEBBA, down from 78% in the first atlas.

Throughout the Mid-Atlantic, those grasslands that do remain are largely located on unprotected private lands. There are several grassland bird species with less than 1% of their potential habitat falling within protected natural lands (GAP status 1 or 2) in Maryland, Delaware and New Jersey. These include the upland sandpiper (*Bartramia longicauda*), grasshopper sparrow (*Ammodramus savannarum*), vesper sparrow (*Pooecetes gramineus*), savannah sparrow (*Passerculus sandwichensis*), Henslow's sparrow (*Ammodramus henslowii*), dickcissel (*Spiza americana*), bobolink (*Dolichonyx oryzivorus*), and eastern meadowlark (*Sturnella magna*) (McCorkle et al. 2006).

Conservation of grassland habitats and changes in management practices can maintain good quality habitat for these rare birds. Because farmland has become fragmented, most remaining grasslands have become smaller and isolated and are no longer suitable for many species requiring large tracts of grassland.

Upland Game Birds

With the notable exception of wild turkey, which uses more extensively forested habitats, upland game birds have declined sharply in Delaware.

Of highest concern in the state, and rangewide, is the continued steep decline and range contraction of northern bobwhite (*Colinus virginianus*). Historically, this species did well in habitat mosaics of agricultural and natural cover, with hedgerows, fallow areas, and old fields interspersed with active cropland. With the industrialization of agriculture and a large increase in suburban development, bobwhite have lost most of their habitat in northern Delaware, retracting from their historic range north of the C&D canal. DNREC Division of Fish and Wildlife has developed a Northern Bobwhite Focus Area at Cedar Swamp Wildlife Area in order to provide habitat for this species. The National Bobwhite Quail Initiative (NBCI) is a unified range-wide strategy of 25 state wildlife agencies, with numerous conservation group and research institution partners, to achieve widespread restoration of native grassland habitats and huntable populations of wild quail (The National Bobwhite Technical Committee 2011). Recent studies indicate that northern bobwhite is useful as an "umbrella species" for other shrubland and grassland-associated birds, including grasshopper sparrow and dickcissel (Crosby et al. 2015).

American woodcock (*Scolopax minor*) also has a shrinking distribution in Delaware. An American Woodcock nesting habitat model developed in a recent Pennsylvania study indicated that chosen

nest sites were characterized by a significantly lower stem count of invasive species, compared to random sites. In addition, successful nest sites had mean invasive cover of 30%, while unsuccessful nests averaged 56% invasive cover. The birds in this study tended to nest most often in arrowood *(Viburnum dentatum*) and spicebush (*Lindera benzoin*) cover, and avoided bush honeysuckles (*Lonicera* sp.) and multiflora rose (*Rosa multiflora*) (Miller 2011). The continued spread of invasive woody plants throughout Delaware, combined with the impending threat of the Viburnum leaf beetle represent further threats to woodcock breeding in the state. A *Woodcock Management Plan* (http://timberdoodle.org/) has been developed for this species.

Shrubland Birds

Table 1. 13 Delaware Shrubland Bird SGCN

Shrubland Birds (10)	
Coccyzus erythropthalmus	Black-billed Cuckoo
Colinus virginianus	Northern Bobwhite
Empidonax traillii	Willow Flycatcher
Icteria virens	Yellow-breasted Chat
Pipilo erythrophthalmus	Eastern Towhee
Scolopax minor	American Woodcock
Setophaga discolor	Prairie Warbler
Spizella pusilla	Field Sparrow
Toxostoma rufum	Brown Thrasher
Vermivora cyanoptera	Blue-winged Warbler

Shrubland birds have declined throughout the US during the past several decades. According to the Northeast RSGCN list the only shrubland bird species for which the region has "high responsibility" is the Blue-winged Warbler, with 48% of the continental population in the northeast.

Forest Birds

Along with many other species groups, forest birds have been considered in several regional and national plans and programs. The Northeast RSGCN Prioritization Framework considered the Wood Thrush, Scarlet Tanager, and Cerulean Warbler to be high responsibility species for the region. These and many other forest species are known to be sensitive to fragmentation and edge effects, thus making human activities such as roads and development important threats. According to the *Conservation Assessment* (Anderson and Olivero Sheldon 2011) there have been substantial changes, both increases and declines, in forest bird abundances over the past 40 years. Species abundance changes have been correlated with degree of fragmentation, with the road-fragmented oak-pine forests showing declines in 11 species and increases in 10 species.

In fragmented landscapes and small habitat patches, direct threats such as predation and brown-headed cowbird (*Molothrus ater*) brood parasitism are higher, creating ecological sinks. Emerging threats include changes in forest composition that may result from invasive insects, diseases and climate change. It is also important to note that forest birds have varying structural requirements with some requiring older or younger seral stages, or different levels of structural diversity.

Table 1. 14 Delaware Forest Bird SGCN

Forest Birds	
Colaptes auratus	Northern Flicker
Icterus galbula	Baltimore Oriole
Myiarchus crinitus	Great Crested Flycatcher
Tyrannus tyrannus	Eastern Kingbird
Vireo gilvus	Warbling Vireo
Forest Interior Birds	
Buteo lineatus	Red-shouldered Hawk

Certhia Americana	Brown Creeper
Pheucticus ludovicianus	Rose-breasted Grosbeak
Piranga olivacea	Scarlet Tanager
Piranga rubra	Summer Tanager
Setophaga cerulean	Cerulean Warbler
Setophaga dominica	Yellow-throated Warbler
Vireo flavifrons	Yellow-throated Vireo
Buteo platypterus	Broad-winged Hawk
Forest Interior Understory Birds	
Bonasa umbellus	Ruffed Grouse
Catharus fuscescens	Veery
Empidonax virescens	Acadian Flycatcher
Geothlypis Formosa	Kentucky Warbler
Helmitheros vermivorum	Worm-eating Warbler
Hylocichla mustelina	Wood Thrush
Mniotilta varia	Black-and-white Warbler
Parkesia motacilla	Louisiana Waterthrush
Setophaga citrine	Hooded Warbler
Setophaga ruticilla	American Redstart
Forest Interior Wetlands Birds	
Limnothlypis swainsonii	Swainson's Warbler
Protonotaria citrea	Prothonotary Warbler
Setophaga Americana	Northern Parula

Pine Specialist Birds	
Melanerpes erythrocephalus	Red-headed Woodpecker
Sitta pusilla	Brown-headed Nuthatch

Forest Interior Birds

Bird species sensitive to forest fragmentation are sometimes referred to as forest interior-dwelling (FID) species or forest area-dependent (FAD) species. There are some species that are sensitive to forest patch isolation, requiring a large amount of overall forest cover, but which do not necessarily require forest interior, so forest area-dependent (FAD) is a broader term that also includes these species. Data on forest area requirements of Mid-Atlantic bird species was summarized by Robbins et al. (1989).

For coastal Maryland, Bushman and Therres (1988) established a list of 19 forest interior breeding birds, which was later supplemented by Jones et al. (2000), who increased the list to 25 species. McCorkle et al. (2006) identified 26 Forest Area Dependent (FAD) breeding bird species that occur in the Delaware / Maryland / New Jersey area. Table 1.15 includes 32 Delaware species that have been identified by one or more of these sources. Of these, 24 species (75%) are listed as SGCN.

Table 1. 15 Forest Area-Dependent Birds in Delaware

Common Name	Scientific Name	Source	DE Breeding Status	DE SGCN Status
Red-shouldered Hawk	*Buteo lineatus*	ALL	Breeds	Yes
Broad-winged Hawk	*Buteo platypterus*	Jones et al.	Rarely Breeds	Yes
Whip-poor-will	*Caprimulgus*	Bushman & Therres, Jones et	Breeds	Yes

	vociferous	al.		
Canada Warbler	*Cardellina Canadensis*	McCorkle et al.	Migrant	Yes
Veery	*Catharus fuscescens*	Jones et al., McCorkle et al.	Breeds	Yes
Brown Creeper	*Certhia Americana*	Jones et al., McCorkle et al.	Rarely Breeds	Yes
Acadian Flycatcher	*Empidonax virescens*	ALL	Breeds	Yes
Kentucky Warbler	*Geothlypis formosa*	ALL	Breeds	Yes
Worm-eating Warbler	*Helmitheros vermivorum*	ALL	Breeds	Yes
Wood Thrush	*Hyocichla mustelina*	Jones et al., McCorkle et al.	Breeds	Yes
Swainson's Warbler	*Limnothlypis swainsonii*	ALL	Rarely Breeds	Yes
Black-and-White Warbler	*Mniotilta varia*	ALL	Breeds	Yes
Louisiana Waterthrush	*Parkesia motacilla*	ALL	Breeds	Yes
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	McCorkle et al.	Rarely Breeds	Yes
Scarlet Tanager	*Piranga olivacea*	ALL	Breeds	Yes
Summer Tanager	*Piranga rubra*	McCorkle et al.	Breeds	Yes
Prothonotary Warbler	*Protonotaria citrea*	ALL	Breeds	Yes

Northern Parula	*Setophaga americana*	ALL	Breeds	Yes
Black-throated Blue Warbler	*Setophaga caerulescens*	McCorkle et al.	Migrant	Yes
Cerulean Warbler	*Setophaga cerulea*	Jones et al., McCorkle et al.	Breeds	Yes
Hooded Warbler	*Setophaga citrina*	ALL	Breeds	Yes
American Redstart	*Setophaga ruticilla*	ALL	Breeds	Yes
Black-throated Green Warbler	*Setophaga virens*	Jones et al.	Migrant	Yes
Yellow-throated Vireo	*Vireo flavifrons*	ALL	Breeds	Yes
Pileated Woodpecker	*Dryocopus pileatus*	ALL	Breeds	No
Northern Waterthrush	*Parkesia noveboracensis*	McCorkle et al.	Migrant	No
Hairy Woodpecker	*Picoides villosus*	ALL	Breeds	No
Blue-gray Gnatcatcher	*Polioptila caerulea*	McCorkle et al.	Breeds	No
Ovenbird	*Seiurus aurocapilla*	ALL	Breeds	No
White-breasted Nuthatch	*Sitta carolinensis*	McCorkle et al.	Breeds	No
Barred Owl	*Strix varia*	ALL	Breeds	No
Red-eyed Vireo	*Vireo olivaceus*	ALL	Breeds	No

Heckscher (2000) conducted point count surveys of birds in the Great Cypress Swamp, the largest remaining contiguous forest area in Delaware, finding a total of 73 species, of which seven of the

top 10 most abundant species were forest-dependent Neotropical migrants. This study represents an important baseline survey breeding species of coastal plain forests.

Despite many forest area-dependent species still being relatively common, there has been a general decline of 63% of Neotropical migrant species since 1966 (USGS Breeding Bird Survey). Some flagship species for this decline include two that breed in Delaware: Wood Thrush (*Hylocichla mustelina*) and Cerulean Warbler (*Setophaga cerulea*).

Many species of forest area dependent birds are neotropical migrants. Other species include the Eastern Whip-poor-will (*Caprimulgus vociferus)* as a well as several hawk and woodpecker species. Although there are survival pressures on these species throughout their annual cycle, habitat loss and forest fragmentation on their breeding grounds is certainly playing a critical role. Jones et al. (2000) outlines in detail conservation measures necessary to conserve the remaining forest interior habitats in this region.

Aerial Insectivores

Table 1. 16 Delaware Aerial Insectivore SGCN

Aerial Insectivores	
Caprimulgus carolinensis	Chuck-will's-widow
Caprimulgus vociferous	Eastern Whip-poor-will
Chaetura pelagica	Chimney Swift
Chordeiles minor	Common Nighthawk
Petrochelidon pyrrhonota	Cliff Swallow
Riparia riparia	Bank Swallow

Birds whose diet consists primarily of aerial invertebrates have declined dramatically, especially in the northeast (Nebel et al. 2010). The reason for this decline are not well understood, but potential climate change-related effects have been suggested as many of these species are long-distance migrants. Some of these species (Common Nighthawk, Chimney Swift) depend nearly exclusively

on buildings and structures in urban areas for breeding sites, while others (Cliff Swallow, Barn Swallow, Bank Swallow, Purple Martin) depend to a large extent on anthropogenic nesting habitats.

Cornell's Nestwatch program is tracking nesting success of aerial insectivores that use nest boxes or artificial structures rangewide through their volunteer network. The Nightjar Survey Network, a nationwide monitoring effort for nightjars, coordinates standardized survey routes for singing nightjars, but has no routes established in Delaware as of 2015.

Migrant Passerines

Neotropical Migrants	
Cardellina canadensis	Canada Warbler
Catharus bicknelli	Bicknell's Thrush
Contopus cooperi	Olive-sided Flycatcher
Empidonax minimus	Least Flycatcher
Setophaga caerulescens	Black-throated Blue Warbler
Setophaga castanea	Bay-breasted Warbler
Setophaga fusca	Blackburnian Warbler
Setophaga pensylvanica	Chestnut-sided Warbler
Setophaga tigrina	Cape May Warbler
Setophaga virens	Black-throated Green Warbler
Vermivora chrysoptera	Golden-winged Warbler

Delaware provides critical stopover habitat for neotropical and temperate passage migrant songbirds. An extensive point count study by McCann et al. (1993) was the first to quantify significantly higher abundance and species richness of migrants at bayshore sites as compared to inland or ocean shore areas. More recent studies by LaPuma et al. (2012) and Buler and Dawson (2014) using weather surveillance radar to assess stopover distributions of landbirds during fall, showed that a high density of birds consistently use significant portions of New Castle, Kent, and Sussex Counties for stopover between migratory flights. The Delaware Piedmont, coastal forests

along the Delaware Bay, and the Nanticoke Watershed appear to be especially important stopover areas (Heckscher pers. comm.).

Migrant Raptors

Table 1. 17 Delaware Migratory and Wintering Raptor SGCN

Migratory / Wintering Raptors	
Accipiter gentilis	Northern Goshawk
Aegolius acadicus	Northern Saw-whet Owl
Asio otus	Long-eared Owl
Bubo scandiacus	Snowy Owl
Buteo lagopus	Rough-legged Hawk
Falco peregrinus	Peregrine Falcon
Accipiter striatus	Sharp-shinned Hawk
Aquila chrysaetos	Golden Eagle
Falco columbarius	Merlin

Large numbers of migrating raptors pass through Delaware each year, with especially large numbers observed in the fall. Two hawk watches in Delaware are operated by a collaboration between DNREC Division of Fish and Wildlife, DNREC Division of Parks and Recreation, the Delmarva Ornithological Society, and The Delaware Nature Society (DNS). The Ashland Hawk Watch is located at the DNS Ashland Nature Center in the Red Clay Valley of the Piedmont, and has documented large flights of broad-winged hawks during fall migration. The Cape Henlopen Hawk Watch is located along the Atlantic Ocean shore of Cape Henlopen State Park and documents numerous raptors crossing over Delaware Bay from Cape May, as well as those migrating down the western shore of the Bay.

SGCN migrant raptors include sharp-shinned hawk (*Accipiter striatus*), which has nested, albeit rarely in the Delaware Piedmont, but which is much more frequent as a migrant; broad-winged

hawk (*Buteo platypterus*), a Neotropical migrant raptor that concentrates heavily during migration, making it susceptible to stochastic events; red-shouldered hawk (*Buteo lineatus*); and golden eagle (*Aquila chrysaetos*). Major threats to these species include collisions with wind turbines and communications towers and loss of stopover foraging and roosting habitat.

Other Wintering Birds

Wintering Coastal Birds	
Calidris maritime	Purple Sandpiper
Gavia immer	Common Loon
Gavia stellate	Red-throated Loon
Phalacrocorax carbo	Great Cormorant
Podiceps auritus	Horned Grebe
Wintering Passerines	
Carpodacus purpureus	Purple Finch
Euphagus carolinus	Rusty Blackbird
Passerella iliaca	Fox Sparrow
Plectrophenax nivalis	Snow Bunting
Spizella arborea	American Tree Sparrow
Sitta canadensis	Red-breasted Nuthatch
Spinus pinus	Pine Siskin

Several SGCN birds are regular winter visitors in Delaware. Irruptive species such as pine siskin (*Carduelis pinus*), and red-breasted nuthatch (*Sitta canadensis*) are very abundant some years and absent, or nearly so, in others. These birds are grouped together here even though they may use different habitats because their seasonal presence in the state dictates different management actions than those for resident species.

Reptiles and Amphibians

Reptile and Amphibian Diversity of Delaware

Evidence indicates that there are world-wide declines in amphibian (Stuart et al. 2004) and reptile populations and a need to identify the specific causes and impacts of these declines is warranted (Gibbons et al. 2000, LaRoe et al. 1995, USGS 1995). There is a recognized national and regional need for advocacy focused on conservation of amphibians and reptiles and the use of an ecosystem approach to incorporate species protection into existing management plans (NEPARC 2004, NEPARC 2009). An estimated 35% of amphibians that are dependent on aquatic habitats are rare or imperiled nationally (TNC 1996, Abell et al. 2000). LaRoe et al. (1995) found that 45% of the nation's turtle species are in need of conservation action, with many species experiencing significant population and distribution declines over the last century. Moreover, vernal pools, the habitat for many amphibian species and some reptile species, are declining in the Northeast (Calhoun and Klemens 2002). Results from a long term study of amphibian occupancy rates on National Wildlife Refuges, a place where anthropogenic threats should be minimal, documented a 3.7% overall decline in amphibian occupancy at study sites (Adams et al. 2013). With this level of decline, 50% of the sites would be expected to be unoccupied within 27 years.

A total of 63 amphibian and reptile species are native to Delaware. Of these, 11 are listed by the state as endangered and five are also federally listed. The status of Delaware's amphibian and reptile species remains poorly documented. White and White (2007) provided county-level occurrence and distributional maps. Threats to Delaware's herps include habitat loss and fragmentation, disease, and climate change. The range, habitats, status and ecology of Delaware's herpetofauna are reviewed in White and White (2007).

Based on GAP analysis of habitat models, all herp taxa are poorly represented within protected natural areas in the Delaware, Maryland and New Jersey region. Amphibians appear to be in the worst shape, with over 95% of amphibian species having less than 10% of their potential habitat occurring within protected natural lands (GAP Status 1 and 2) (McCorkle et al. 2006).

The northeastern region RSGCN list includes 29 reptile species: 14 turtles, two lizards, and 13 snakes. Of these species, the wood turtle, northern diamondback terrapin, and northern black racer are Delaware species considered to be of high regional responsibility for management as well as high or very high regional conservation concern. These high-priority reptiles, along with many of the other reptilian RSGCN, are threatened by habitat loss and fragmentation, pollution, disease, and illegal harvest.

Amphibians

Table 1. 18 Delaware Amphibian SGCN

Amphibians (18)	
Ephemeral Wetland Obligate Amphibians	
Ambystoma maculatum	Spotted Salamander
Ambystoma opacum	Marbled Salamander
Ambystoma tigrinum	Tiger Salamander
Hyla gratiosa	Barking Treefrog
Lithobates sylvaticus	Wood Frog
Groundwater Lotic Amphibians	
Desmognathus fuscus	Northern Dusky Salamander
Eurycea longicauda	Longtail Salamander
Pseudotriton montanus	Mud Salamander
Pseudotriton ruber	Red Salamander
Other Amphibians	
Acris crepitans	Northern Cricket Frog
Anaxyrus fowleri	Fowler's Toad
Eurycea bislineata	Northern Two-lined Salamander
Hemidactylium scutatum	Four-toed Salamander
Hyla chrysoscelis	Cope's Gray Treefrog

Lithobates virgatipes	Carpenter Frog
Notophthalmus viridescens	Eastern Newt
Pseudacris kalmi	New Jersey Chorus Frog
Rana kauffeldi	Atlantic Coast Leopard Frog

Delaware is home to 31 species of amphibians, of which 18 (58%) meet the criteria for SGCN.

The RSGCN list for the Northeast includes 35 species of amphibians: of these 28 are salamanders, five are frogs and two are toads. Amphibian species in the Northeast are under many threats, including wetland loss, water pollution, groundwater contamination, exurban and suburban sprawl, increased habitat fragmentation from roads and new human developments, and exotic, non-native diseases.

The Eastern Spadefoot is facing population declines and loss of habitat in the Northeast. The Northern Leopard Frog is also a regional species of concern that is exhibiting population declines in the Northeast, but is common elsewhere in the U.S.

In terms of rarity and vulnerability to human impacts, vernal pool-breeding amphibians represent an important species assemblage. Several species are of particular conservation concern, including the spotted salamander (*Ambystoma maculatum*), marbled salamander (*Ambystoma opacum*), tiger salamander (*Ambystoma tigrinum*) and barking treefrog (*Hyla gratiosa*), all of which depend upon forests and seasonal wetlands for their survival.

Figure 1. 2 Barking Treefrog (*Hyla gratiosa*) is a southeastern species that reaches the northern edge of its range in Delaware and is entirely dependent on Coastal Plain seasonal ponds for breeding habitat. Photo: Jim White

The Blackbird-Millington Corridor, which spans the boundary between Maryland and Delaware on the northern part of the Coastal Plain, includes the largest concentration of Coastal Plain seasonal ponds in the project area. These seasonal wetlands and the surrounding matrix of hardwood forest represented the most significant rare amphibian species hotspot in the MDN-GAP project area, and much of the area remains unprotected (McCorkle et al. 2006). Because the topography of the area is very flat, its forests and seasonal wetlands are especially vulnerable to development. Despite the fact that significant portions of this corridor occur on state-owned forest land and wildlife management area land, all of the species mentioned above have less than 10% of their predicted distributions occurring within protected natural lands (GAP status 1 or 2) (McCorkle et al 2006).

Barking treefrog (*Hyla gratiosa*), Cope's gray treefrog (*Hyla chrysoscelis*), Eastern narrowmouth toad (*Gastrophryne carolinensis*) and carpenter frog (*Rana virgatipes*) all have less than 5% of their predicted regional distributions occurring within protected natural lands (GAP status 1 or 2) (McCorkle et al. 2006).

Upland forested buffers are extremely important for conservation of ephemeral wetland breeders. For example, adult salamanders of six *Ambystoma* species were found an average of 125 m from the edge of aquatic habitats during the non-breeding portions of their life-cycles, such that a wetland buffer zone of 164 m (534 ft) could be expected to encompass the majority of the population of these salamanders during their entire life cycle (Semlitsch 1998). It also important to consider corridors to allow gene flow between populations, and when possible, to protect entire complexes of breeding wetlands as well as their forest matrix.

Several of Delaware's amphibian SGCN are dependent on groundwater-fed, lotic habitats associated with springs, seeps, and stream headwaters. These include the long-tail salamander, mud salamander, northern dusky salamander, and red salamander.

Concern over declines in amphibian populations has prompted the initiation of amphibian monitoring programs throughout North America and around the world. Volunteers with the Delaware Amphibian Monitoring Program (DAMP), part of the North American Amphibian Monitoring Program (NAAMP), conduct nighttime surveys of calling frogs and toads around the state each year. Volunteers are assigned a driving route in one portion of the state, and conduct surveys along that route. DAMP volunteers have been surveying calling frogs and toads in Delaware since 1997.

Delaware frog call survey data from 2001 to 2011 were analyzed (along with data from several other states in the northeast) to detect population trends of frog species. Delaware results included significant increasing trends for green treefrog (*Hyla cinerea*), spring peeper (*Pseudacris crucifer*), and the gray treefrog complex (*Hyla versicolor / chrysoscelis*) and significant decreasing trends for the chorus-frog complex (*Pseudacris feriarum/ kalmi*) (Weir et al. 2014).

Snakes and Lizards

Fourteen species of snakes and lizards (collectively known as scaled reptiles, or squamates) are considered SGCN in Delaware. A subset of these species are found entirely or primarily in sandy habitats on the Coastal Plain.

Table 1. 19 Delaware Snake and Lizard SGCN

Sand Specialist Snakes and Lizards (5)	
Cemophora coccinea	Scarletsnake

Heterodon platirhinos	Eastern Hog-nosed Snake
Pantherophis guttatus	Red Cornsnake
Scincella lateralis	Ground Skink
Storeria occipitomaculata	Red-bellied Snake
Other Snakes and Lizards (9)	
Agkistrodon contortrix	Copperhead
Lampropeltis getula	Common Kingsnake
Lampropeltis triangulum	Milksnake
Nerodia erythrogaster	Plain-bellied Watersnake
Opheodrys aestivus	Rough Greensnake
Plestiodon laticeps	Broad-headed Skink
Regina septemvittata	Queen Snake
Thamnophis sauritus	Eastern Ribbonsnake
Virginia valeriae	Smooth Earthsnake

Accurate population assessments are needed to determine the status of many of the species in this group.

Turtles

Table 1. 20 Delaware Turtle SGCN

Wetland and Riparian Turtles (3)	
Clemmys guttata	Spotted Turtle
Glyptemys insculpta	Wood Turtle

Glyptemys muhlenbergii	Bog Turtle
River and Bay Turtles (2)	
Malaclemys terrapin	Diamondback Terrapin
Pseudemys rubriventris	Northern Red-bellied Cooter
Terrestrial Turtles (1)	
Terrapene carolina	Eastern Box Turtle

Figure 1. 3 Bog turtle (*Glyptemys muhlenbergii).* Photo: Jim White

The bog turtle (*Glyptemmys mulenbergii*) is a small, semi-aquatic turtle that inhabits freshwater wetland habitats that have soft muck and pedestal vegetation. Unfortunately, the species is in

trouble due to loss of habitat, wetland alteration and illegal collection for the pet trade. The U.S. Fish and Wildlife Service listed the northern population as federally threatened in 1997, with a recovery plan prepared for the northern population in 2001 (USFWS 2001). There are only two known locations in Delaware where bog turtles are reproducing.

The DNREC DFW Wildlife Species Conservation & Research Program has been monitoring bog turtles since 1992 and monitors known sites with visual surveys, trapping and radio telemetry to keep track of population status and evaluates potential new habitats to see if bog turtles are present. DNREC Division of Fish & Wildlife also works with landowners with bog turtle habitats to encourage bog turtle populations by maintaining optimal vegetation and habitat quality.

Like the bog turtle, the spotted turtle (*Clemmys guttata*) is associated with wetlands, and is generally found within 500 m of a wetland (Whitlock 1994). Although far more widespread in Delaware than bog turtles, spotted turtles remain a species of concern due to habitat loss and illegal collection for the pet trade.

The Wood Turtle has been the subject of recent regional conservation efforts sponsored by the Regional Conservation Needs (RCN) Grant Program and the Northeast Partners in Amphibian and Reptile Conservation (NEPARC) in response to evidence of population declines. A Wood Turtle Working Group was formed in 2009, and a status assessment and conservation planning process was completed for this species in 2013 (Jones et al. 2014). While this species is not known historically from Delaware, there is some possibility that it may occur during dispersal from Pennsylvania populations.

Diamondback terrapins, once a seasonal food item across Delmarva, are no longer routinely trapped for food, but continue to face beach development, bulk-heading and traffic as major threats to their breeding areas. The DNREC Division of Parks and Recreation and Division of Fish and Wildlife erected turtle fencing to minimize road mortality during the nesting season along the busy barrier beach highway at Delaware Seashore State Park. Nesting habitat was also added to the bayside of the highway in an effort to deter females from crossing the road. A conservation assessment is currently underway for this species in the Northeast, funded by the Northeast Regional Conservation Needs program and recognized as a priority by the Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC).

Sea Turtles

Table 1. 21 Delaware Sea Turtle SGCN

Sea Turtles (5)	
Caretta caretta	Loggerhead
Chelonia mydas	Green Turtle
Dermochelys coriacea	Leatherback
Eretmochelys imbricata	Hawksbill
Lepidochelys kempii	Kemp's Ridley Sea Turtle

Four species of marine sea turtles are included on the RSGCN list (Loggerhead, Green, Leatherback, and Kemp's Ridley), all of which are protected under the ESA. Because of their broad distributions but significant range-wide declines, these species are considered to be low regional responsibility but of very high conservation concern in the Northeast. Information about their distribution, abundance, migratory movements and population characteristics are collected by USFWS, NMFS and other partners to implement actions identified in the species' Federal Recovery Plans.

Sea turtles visit Delaware's estuarine and marine waters during the warmer months (June through October). The Delaware Estuary has an abundance of benthic invertebrates which are the primary prey for loggerheads, Kemp's ridley and juvenile green turtles. Because leatherbacks (*Dermochelys coriacea*) feed primarily upon jellyfish their occurrence in Delaware waters is more pelagic although sightings in the lower DE Bay have occurred, likely tied to jellfish blooms.

In Delaware Bay, loggerheads (*Caretta caretta*) occur in the greatest number and the estuary provides important developmental habitat for juveniles. The estuary may be equally important for adults as evidenced by satellite-tagged individuals that travelled to Delaware Bay and set up "home ranges," some staying as long as several months before heading offshore or southward when water temperatures begin dropping in the fall (Martin 2010). Survey data compiled from 1996-1997 by J.R. Spotila indicate that a high density (21-33 animals / 100 km^2) of turtles, primarily loggerheads, are found in the Delaware Bay during the summer (Spotila et al. 2007).

Research indicates that loggerhead sea turtles have an apparent affinity for channel habitat in other estuarine and near shore habitats along the U.S. Atlantic Coast (PSEG 1997, Byles 1988). This makes them vulnerable to ship strikes and channel dredging activities. Baseline data is needed on sea turtles in Delaware, especially with regard to periods of peak abundance, population size and habitat usage.

Fish

NOAA (2011) estimates that 130 species of fish use the estuarine habitats of the Delaware River and Bay. The shallow waters of Delaware's Inland Bays provide habitat for at least 112 species of fish (Delaware Center for the Inland Bays 2011). Five fish species may be extirpated from the Delaware River Basin: pirate perch (*Aphredoderus sayanus*), mud sunfish (*Acantharchus pomotis*), blackbanded sunfish (*Enneacanthus chaetodon*), swamp darter (*Etheostoma fusiforme*), and longnose gar (*Lepisosteus osseus*) (Cooper 1983; Horwitz et al. 2008).

101 fish species have been identified as Northeast Regional Species of Greatest Conservation Need (RSGCN), making them one of the most numerous vertebrate groups listed. These fish taxa included representatives of all of the major fish families found in the Northeast, with certain families (Percidae, Cyprinidae, Salmonidae) particularly well represented.

NOAA's National Marine Fisheries Service (NMFS) provides an Essential Fish Habitat (EFH) Mapper tool online for viewing the spatial representations of managed fish species, their life-stages and important habitats, as well as links to supporting materials, including fishery management plans, and the ability to download GIS data.

The Atlantic States Marine Fisheries Commission (ASMFC) manages coastal (0-3 miles) inshore migratory species, and the Mid-Atlantic Fisheries Management Council (MAFMC) maintains jurisdiction from 3 to 200 miles off the coast. The MAFMC has Fisheries Management Plans (FMPs) for Atlantic Mackerel, squid and Butterfish; Bluefish; Spiny Dogfish (joint with the NEFMC); Summer Flounder, Scup and Black Sea Bass; and Tilefish (available online at *http://www.mafmc.org/mid-atlantic/fmp/fmp.htm*). The ASMFC manages 22 species or groups of species for conservation, and has approved interstate FMPs for several of them (e.g. striped bass; available online at *http://www.asmfc.org/*). All of these regional FMPs assess the abundance and distribution for each species and describe conservation measures to address any threats to the fish stocks.

The Atlantic Coastal Fish Habitat Partnership (ACFHP) developed a Conservation Strategic Plan for 2012-2016, which proposed key conservation strategies to address serious threats to fish habitats along the Atlantic coast (ACFHP 2011a). ACFHP also developed an accompanying 2012-2013 Implementation Plan, a subset of the Conservation Strategic Plan, which described specific objectives and actions to be accomplished during the 2012-2013 period (ACFHP 2012b). The Association of Fish and Wildlife Agencies (AFWA) published a National Fish Habitat Action Plan (AFWA 2006), which detailed specific actions for the restoration and conservation of fish habitat across the United States. The National Fish Habitat Partnership (NFHP) recently published a second edition of the habitat action plan (NFHB 2012) with new conservation and management actions and updates on progress since the first plan. In 2010, NFHP conducted the first ever national assessment

of fish habitat, Through a Fish's Eye: The Status of Fish Habitats in the United States (NFHB 2010), which detailed the status of fish habitats across the country and served to accomplish one of the major goals of AFWA's 2006 Action Plan.

Human activities continue to impact aquatic systems across the Northeast, and fish populations face many threats. The recent AFS and United States Geological Survey (USGS) analysis (*http://www.actionbioscience.org/biodiversity/walsh.html*) (Walsh et al. 2009) describes the most significant threats to freshwater fish. Destruction or modification of habitat, which can result in loss of populations and reductions in species range, includes dam construction, stream channelization, mining, conversion of forests to agriculture, and urban and suburban development. Pollution from point and non-point source contaminants in run-off reduces water quality to the point where only highly tolerant fish species survive. Sedimentation of fine particulates can also smother bottom substrates, causing declines in bottom-dwelling species that require clean substrates and good water quality.

Introduction of non-native species, which may result in hybridization, competition, and predation, has the potential to impact native species. Examples of aquatic invasive that may impact SGCN fishes include the Northern snakehead (*Channa argus*) (found in the Nanticoke and Christina drainages) and the rusty crayfish (*Orconectes rusticus*). The Mid-Atlantic Panel on Aquatic Nuisance Species created a list of 49 "Species of Interest" for the region. Disease or parasitism such as whirling disease (introduced from Europe) has affected many wild and hatchery populations of trout and salmon species in the United States and Canada. Overharvesting for commercial, recreational, scientific, or educational purposes has also historically affected some species such as the federally endangered shortnose sturgeon and Atlantic sturgeon. Eutrophication and resulting hypoxia can create unsuitable conditions in summer months for sensitive species, especially in shallow estuarine waters..

Global climate change and associated changes in weather and rainfall patterns across the Northeast have the potential to alter water quality and quantity in many streams, lakes, and rivers, with resulting detrimental effects for many fish species. Climate change effects in estuarine and marine habitats can affect currents, water temperature, and many other factors that may result in impacts to SGCN. Climate change can also exacerbate the other threats listed above.

Freshwater Fish

Table 1. 22 Delaware Frewater Fish SGCN

Freshwater Fish (23)	
Acantharchus pomotis	Mud Sunfish
Amia calva	Bowfin
Cottus bairdii	Mottled Sculpin
Cottus caeruleomentum	Blue Ridge Sculpin
Cyprinella analostana	Satinfin Shiner
Enneacanthus chaetodon	Blackbanded Sunfish
Enneacanthus obesus	Banded Sunfish
Etheostoma fusiforme	Swamp Darter
Etheostoma vitreum	Glassy Darter
Exoglossum maxillingua	Cutlip Minnow
Hybognathus regius	Eastern Silvery Minnow
Lampetra aepyptera	Least Brook Lamprey
Lepomis auritus	Redbreast Sunfish
Lethenteron appendix	American Brook Lamprey
Moxostoma macrolepidotum	Shorthead Redhorse
Notropis amoenus	Comely Shiner
Notropis bifrenatus	Bridle Shiner
Notropis chalybaeus	Ironcolor Shiner
Notropis procne	Swallowtail Shiner
Noturus insignis	Margined Madtom
Percina peltata	Shield Darter

Semotilus corporalis	Fallfish
Umbra pygmaea	Eastern Mudminnow

Cool-cold Headwater Species

Sculpin (Cottidae) often co-occur with brook trout but may tolerate slightly warmer stream temperatures. Both slimy and mottled sculpin occur in Delaware and have been documented as potential host fish for several mussel species, including dwarf wedgemussel (*Alasmidonta heterodon*), brook floater (*Alasmidonta varicosa*), and creeper (*Strophitus undulatus*) (Nedeau et al. 2000; CTDEP 2003). Sculpin have small home ranges and need networks of connected headwaters and small streams to maintain genetic diversity and minimize the risk of localized extinction.

Transitional Cool and Warm Backwater Species

These species thrive in cool or warm sluggish headwater streams and in backwaters of small and large rivers. Bridle shiner (*Notropis bifrenatus*) were once abundant in the Delaware Basin but now are considered rare. Declines have been rapid and range-wide over the past 50 years (Cooper 1983; PNHP 2010). Recent surveys within the Delaware River basin have documented bridle shiners in small sluggish warm-water creeks, permanent backwaters within the floodplain, and in beaver ponds. They were often found swimming above and into patches of submerged aquatic vegetation, which are used for cover and during spawning (Horwitz et al. 2008).

While they were never abundant, ironcolor shiner (*Notropis chalybaeus*) distributions have also decreased. Only two populations have been documented recently in the Delaware River basin (Lellis and Johnson 2006; NYDEC 2011). Both shiners spawn over aquatic vegetation (Jenkins and Burkhead 1993). Possible causes of species decline include siltation, loss of aquatic vegetation, and a reduction in critical backwater habitat historically created by beavers (Horwitz et al. 2008; PNHP 2010). Eastern mudminnow *(Umbra pygmaea*) also thrives in vegetated backwater pools and wetlands within the floodplain of major tributaries and the mainstem river (Horwitz et al. 2008). Adjacent land cover, lateral connectivity, and groundwater contribution are important to maintaining vegetation, temperature, and dissolved oxygen in these habitats.

Nest Builders

Several freshwater species, including Delaware's four SGCN sunfish (Centrarchidae) species, as well as margined madtom (*Noturus insignis*) and fallfish (*Semotilus corporalis*) build nests in which to spawn. Some species such as banded (*Enneacanthus obesus*) and black-banded sunfish (*Enneacanthus chaetodon*) prefer spawning habitat in shallow areas with low flow and aquatic vegetation. Margined madtom (*Noturus insignis*) prefer moderate to fast currents over sand and gravel substrates. They are important indicators of the persistence of shallow, fast water habitats and serve as host fish for several freshwater mussel species. Fallfish (*Semotilus corporalis*) also serves as a host fish for freshwater mussels (Strayer and Jirka 1997; CTDEP 2003).

Nest builders require maintenance of suitable nesting substrate and are sensitive to extreme high and low flow events that could impact eggs and fry. Changes to land cover, loss of baseflows, and high flow events during spawning could impact nesting success.

Diadromous Fish

The Delaware River Basin supports ten diadromous fish species, which migrate between freshwater and marine habitats during their life cycles (Cooper 1983; Greene et al. 2009; NOAA 2011).

Anadromous fish, including clupeids (American shad, *Alosa sapidissima*; hickory shad, *A. mediocris*; alewife, *A. pseudoharengus*; and blueback herring, *A. aestivalis*), Atlantic sturgeon (*Acipenser oxyrinchus*), and striped bass (*Morone saxatilis*) spend most of their adult lives at sea before returning to natal rivers to spawn.

Although often referred to as an anadromous species, shortnose sturgeon (*Acipenser brevirostrum*) in the Delaware River are more correctly referred to as an amphidromous species, as they move between freshwater and the bay to feed, but not to spawn. Delaware's catadromous species, American eel (*Anguilla rostrata*), migrates from the ocean into freshwater environments as juveniles. Once mature, they emigrate to spawn in marine environments.

Table 1. 23 Delaware Diadromous Fish SGCN

Diadromous Fish (9)	
Anguilla rostrata	American Eel

Acipenser brevirostrum	Shortnose Sturgeon
Acipenser oxyrinchus oxyrinchus	Atlantic Sturgeon
Alosa aestivalis	Blueback Herring
Alosa mediocris	Hickory Shad
Alosa pseudoharengus	Alewife
Alosa sapidissima	American Shad
Clupea harengus	Atlantic Herring
Morone saxatilis	Striped Bass

Diadromous fish require connectivity between marine and freshwater habitats. The Delaware River is unique among major eastern rivers in that its mainstem is free of dams, allowing these species to access much of their historic spawning habitat. However, overfishing, pollution, and barriers on tributaries have negatively affected diadromous fish populations in the Delaware River Basin, with most populations currently at historic lows (ASMFC 2006; ASMFC 2007). A review of habitat conditions, threats, and recommendations for diadromous fish was completed for the Atlantic coast by Greene et al. (2009).

Historical information and restoration efforts for shad and other anadromous species in northern Delaware tributaries are detailed in Narvaez et al. (2010). American shad are historically known from the Brandywine and Christina watersheds, the Broadkill, and the Nanticoke. American shad from hatcheries have been stocked in the Nanticoke River. A state moratorium on the commercial and recreational harvest of American shad and hickory shad went into effect in February 2000.

Sturgeon populations remain at historic lows as well. The Delaware River spawning population of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is currently estimated at less than 300 adults, down from an estimated 180,000 prior to 1890 (NOAA NMFS n.d.) The New York Bight Distinct Population Segment (DPS) of Atlantic sturgeon (including the Delaware River spawning population) was one of 4 DPSs listed as federally endangered in 2012 (USFWS 2012). Shortnose sturgeon (*Acipenser brevirostrum*) was listed as as federally endangered in 1967 (32 FR4001), with a recovery plan published in December 1998.

Threats to both sturgeon species include vessel strikes and entrainment and impingement in cooling water withdrawal systems. Twenty-nine mortalities of Atlantic sturgeon believed to be the result of

vessel strikes were documented in the Delaware River from 2004 to 2008, and at least 13 of these fish were large adults. A recent study indicated that the loss of only a few adult female Atlantic sturgeon would impact recovery of Atlantic sturgeon in the Delaware River (NOAA NMFS n.d.). The effects of main channel deepening of the Delaware River (both dredging and increased vessel traffic) on sturgeon could be significant.

Estuarine and Marine Fish

The ecology of Delaware's estuarine fishes was extensively reviewed by Able and Fahay (2010). Much foundational information on juvenile life stages was compiled by Wang and Kernehan (1979).

Table 1. 24 Delaware Estuarine and Marine Fish SGCN

Estuarine Fish	
Apeltes quadracus	Fourspine Stickleback
Fundulus heteroclitus	Mummichog
Fundulus luciae	Spotfin Killifish
Fundulus majalis	Striped Killifish
Menidia menidia	Atlantic Silverside
Marine / Estuarine Fish	
Brevoortia tyrannus	Atlantic Menhaden
Centropristis striata	Black Sea Bass
Cynoscion nebulosus	Spotted Seatrout
Cynoscion regalis	Weakfish
Epinephelus nigritus	Warsaw Grouper
Leiostomus xanthurus	Spot
Micropogonias undulatus	Atlantic Croaker
Paralichthys dentatus	Summer Flounder
Pogonias cromis	Black Drum

Pomatomus saltatrix	Bluefish
Pseudopleuronectes americanus	Winter Flounder
Sciaenops ocellatus	Red Drum
Scomberomorus maculatus	Spanish Mackerel
Stenotomus chrysops	Scup
Tautoga onitis	Tautog
Thunnus thynnus	Atlantic Bluefin Tuna

The mummichog (*Fundulus heteroclitus*) is a common fish distributed widely in coastal waters and salt marshes. Mummichogs breed in salt marshes, where they frequently feed on mosquito larvae. Atlantic silverside (*Menidia menidia*), and striped killifish (*Fundulus majalis*) are other common nearshore fish that comprise an important part of the diet of many of the larger commercially important fish in the bay.

The Delaware Bay is an important spawning area for weakfish (*Cynoscion regalis*). Weakfish populations are currently very low compared with historic estimates of abundance, and juvenile weakfish are rarely reaching adulthood in Delaware's Inland Bays (Delaware Center for the Inland Bays 2011). Black drum (*Pogonias cromis*) and white perch (*Morone americana*) also use the bay for spawning, and juveniles use tidal creeks as nursery areas. Several flatfish are common in bay waters, including the SGCN winter flounder (*Pseudopleuronectes americanus*).

Atlantic menhaden (*Brevoortia tyrannus*) are an important component of the marine ecosystem, serving as a food resource for many species of predatory fish.

Sharks

There are 32 species of sharks considered SGCN in Delaware. Global populations of sharks and many other cartilaginous fishes have been severely reduced in recent decades through over-harvest for the commercial market. Many species of sharks of conservation concern use the waters of Delaware Bay and the Atlantic Ocean. A few of these species may be very uncommon as far north as Delaware, however, the high global concern for shark species and potential changes in

distribution and abundance due to climate change warrants their listing even if they are currently rare in Delaware waters.

Table 1. 25 Delaware Shark SGCN

Coastal Sharks (11)	
Carcharhinus isodon	Finetooth Shark
Carcharias Taurus	Sand Tiger Shark
Ginglymostoma cirratum	Nurse Shark
Heptranchias perlo	Sharpnose Sevengill Shark
Hexanchus griseus	Bluntnose Sixgill Shark
Mustelus canis	Smooth Dogfish
Negaprion brevirostris	Lemon Shark
Rhizoprionodon terraenovae	Atlantic Sharpnose Shark
Sphyrna tiburo	Bonnethead Shark
Squalus acanthias	Spiny Dogfish
Squatina dumeril	Angel Shark
Pelagic Sharks (21)	
Alopias superciliosus	Bigeye Thresher Shark
Alopias vulpinus	Thresher Shark
Carcharhinus brevipinna	Spinner Shark
Carcharhinus falciformis	Silky Shark
Carcharhinus leucas	Bull Shark
Carcharhinus limbatus	Blacktip Shark
Carcharhinus longimanus	Oceanic Whitetip Shark
Carcharhinus obscurus	Dusky Shark

Carcharhinus plumbeus	Sandbar Shark
Carcharhinus signatus	Night Shark
Carcharodon carcharias	White Shark
Cetorhinus maximus	Basking Shark
Galeocerdo cuvier	Tiger Shark
Isurus oxyrinchus	Shortfin Mako Shark
Isurus paucus	Longfin Mako Shark
Lamna nasus	Porbeagle Shark
Prionace glauca	Blue Shark
Rhincodon typus	Whale Shark
Sphyrna lewini	Scalloped Hammerhead
Sphyrna mokarran	Great Hammerhead
Sphyrna zygaena	Smooth Hammerhead

The shallow habitats of coastal Delaware Bay are important primary and secondary nursery habitat for sandbar shark (*Carcharhinus plumbeus*) (Merson and Pratt 2001, Rechisky and Wetherbee 2003, NMFS 2009). Sand tiger shark (*Carcharias taurus*), along with smooth (*Mustelus canis*) and spiny dogfish (*Squalus acanthias*) also use the Bay extensively. Researchers have conducted radio-tagging research on sand tiger sharks in Delaware Bay since 2007 as part of the Atlantic Cooperative Telemetry Network (ACT), finding that this species leaves Delaware Bay in fall, with males moving south to Hatteras or beyond, and females moving to offshore waters near the shelf break (Fox et al. 2009, Teter et al. 2015). Several species of pelagic sharks [as classified by Camhi et al. (2009)] regularly visit the waters off of Delaware. All shark species managed by the Atlantic States Marine Fisheries Commission (ASMFC) observations or potentially suitable habitat are included as SGCN.

Invertebrates

Invertebrates account for an exceptionally large proportion of the biodiversity of Delaware. In Pennsylvania, where invertebrate species numbers have been quantified, Rawlins and Bier estimate that invertebrates make up over half of the state's species diversity (53.2%), with plants, algae, fungi and lichens accounting for 40% and vertebrate animals only 3.2% . Among invertebrates, the vast majority are insects (Rawlins and Bier, n.d.)

Insects

There are more than 163,000 species of insects in the U.S. and Canada, but much of this incredible diversity is not yet understood. In adjacent Pennsylvania, insects alone make up an estimated 45.8% of all species in the state, plant or animal, and 76.3% of animal species (Rawlins and Bier, n.d.) The numbers are likely similar in Delaware. Despite this tremendous dominance in terms of biodiversity, the ecology, distribution, and habitat associations of most species remain poorly known.

Highly specialized relationships between insects and host plants can render some insects highly vulnerable to extinction should the host decline. It is presumed, for example, that at least two species of moths have become extinct due to the loss of the American chestnut (Dunn 2005). Similar risks exist for species dependent on plants threatened by invasive species, such as ashes (*Fraxinus* sp.), which may decline in Delaware in the near future as a result of emerald ash borer invasion. Pollinators are dependent on sufficient diversity and abundance of host plants for pollen and nectar, and these relationships are also becoming threatened due to development, invasive species, and other factors.

Dragonflies and Damselflies

Dragonflies and damselflies are relatively well-known in Delaware, thanks largely to the efforts of H.B. White, whose *Natural History of Delmarva Dragonflies and Damselflies* (2011) presents a series of essays on all species known to occur on the peninsula as well as a county distribution checklist. The regional status and habitat associations of northeastern odonates were assessed by White et al. (2014).

Table 1. 26 Delaware Odonate SGCN

Dragonflies & Damselflies (84)	
Aeshna tuberculifera	Black-tipped Darner
Anax longipes	Comet Darner
Argia bipunctulata	Seepage Dancer
Arigomphus villosipes	Unicorn Clubtail
Celithemis elisa	Calico Pennant
Celithemis fasciata	Black Spotted Skimmer
Celithemis verna	Double-ringed Pennant
Chromagrion conditum	Aurora Damsel
Enallagma aspersum	Azure Bluet
Enallagma basidens	Double-striped Bluet
Enallagma daeckii	Attenuated Bluet
Enallagma dubium	Burgundy Bluet
Enallagma geminatum	Skimming Bluet
Enallagma traviatum	Slender Bluet
Enallagma vesperum	Vesper Bluet
Epitheca costalis	Slender Baskettail
Epitheca spinosa	Robust Baskettail

Erythrodiplax minuscula	Little Blue Dragonlet
Gomphaeschna antilope	Taper-tailed Darner
Gomphaeschna furcillata	Harlequin Darner
Gomphus exilis	Lancet Clubtail
Ischnura kellicotti	Lilypad Forktail
Lestes australis	Southern Spreadwing
Lestes congener	Spotted Spreadwing
Lestes eurinus	Amber-winged Spreadwing
Lestes forcipatus	Sweetflag Spreadwing
Lestes inaequalis	Elegant Spreadwing
Lestes rectangularis	Slender Spreadwing
Lestes vigilax	Swamp Spreadwing
Leucorrhinia intacta	Dot-tailed Whiteface
Libellula auripennis	Golden-winged Skimmer
Libellula axilena	Bar-winged Skimmer
Libellula cyanea	Spangled Skimmer
Libellula needhami	Needham's Skimmer
Libellula semifasciata	Painted Skimmer
Nehalennia gracilis	Sphagnum Sprite
Nehalennia integricollis	Southern Sprite
Nehalennia irene	Sedge Sprite
Sympetrum rubicundulum	Ruby Meadowhawk
Sympetrum semicinctum	Band-winged Meadowhawk

Progomphus obscurus	Common Sanddragon
Telebasis byersi	Duckweed Firetail
Celithemis ornata	Ornate Pennant
Macromia taeniolata	Royal River Cruiser
Amphiagrion saucium	Eastern Red Damsel
Archilestes grandis	Great Spreadwing
Basiaeschna janata	Springtime Darner
Boyeria vinosa	Fawn Darner
Cordulegaster bilineata	Brown Spiketail
Cordulegaster diastatops	Delta-spotted Spiketail
Cordulegaster erronea	Tiger Spiketail
Cordulegaster maculata	Twin-spotted Spiketail
Didymops transversa	Stream Cruiser
Enallagma divagans	Turquoise Bluet
Enallagma pallidum	Pale Bluet
Gomphus lividus	Ashy Clubtail
Helocordulia selysii	Selys' Sundragon
Libellula flavida	Yellow-sided Skimmer
Somatochlora filosa	Fine-lined Emerald
Somatochlora linearis	Mocha Emerald
Somatochlora provocans	Treetop Emerald
Stylurus laurae	Laura's Clubtail
Stylurus plagiatus	Russet-tipped Clubtail
Macromia illinoiensis	Swift River Cruiser

Stylogomphus albistylus	Eastern Least Clubtail
Argia moesta	Powdered Dancer
Argia sedula	Blue-ringed Dancer
Argia translata	Dusky Dancer
Calopteryx dimidiata	Sparkling Jewelwing
Dromogomphus spinosus	Black-shouldered Spinyleg
Enallagma weewa	Blackwater Bluet
Gomphus apomyius	Banner Clubtail
Gomphus fraternus	Midland Clubtail
Gomphus rogersi	Sable Clubtail
Lanthus vernalis	Southern Pygmy Clubtail
Neurocordulia obsoleta	Umber Shadowdragon
Stylurus spiniceps	Arrow Clubtail
Aeshna verticalis	Green-striped Darner
Epitheca semiaquea	Mantled Baskettail
Nannothemis bella	Elfin Skimmer
Somatochlora tenebrosa	Clamp-tipped Emerald
Rhionaeschna mutata	Spatterdock Darner
Brachymesia gravida	Four-spotted Pennant
Enallagma durum	Big Bluet
Erythrodiplax berenice	Seaside Dragonlet

A worldwide assessment of the conservation status of odonates conducted by Clausnitzer et al. (2009) found that only about 1 in 10 odonates were currently threatened with extinction according to IUCN criteria, a relatively low percentage compared to other taxa. However, 18% of the

northeastern U.S. odonate fauna is imperiled. Peatlands, low gradient streams and seeps, high gradient headwaters, and larger rivers, are habitats that harbor a disproportionate number of imperiled species in our region and should be considered as priority habitat types for conservation, monitoring, and management (White et al. 2014). In fact, Collins (2014) found that future climate change will significantly impact the range of all 15 northeastern lotic species in his climate modeling study, even assuming unlimited dispersal.

Figure 1. 4 Elfin Skimmer (*Nannothemis bella*) is a state Endangered odonate restricted to Coastal Plain peatlands, especially sea level fens. Photo: Michael Moore

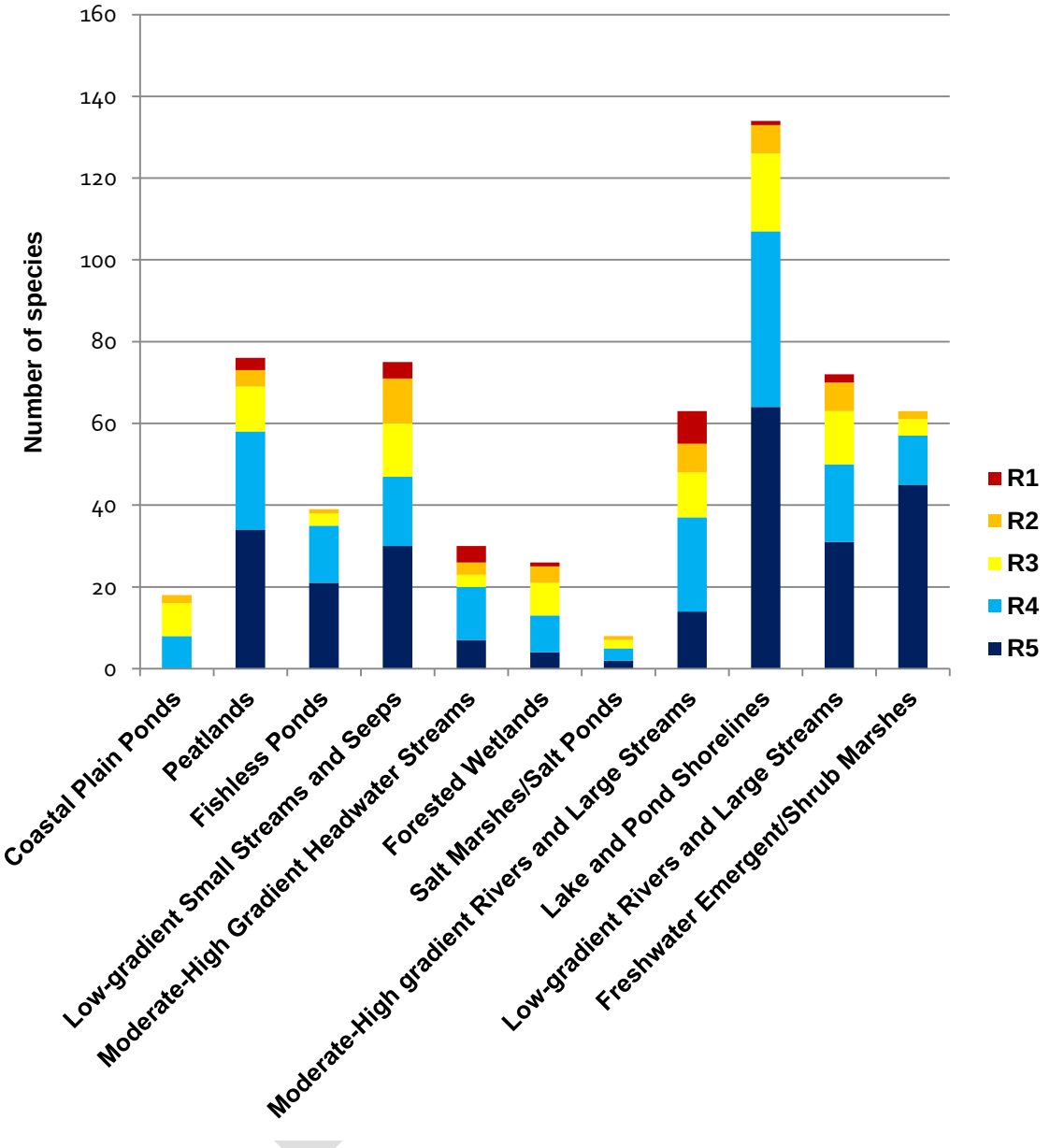


Figure 1. 5 Relative importance of habitat types to dragonflies and damselflies in the Northeast. From White et al. (2014). Regional ranks are depicted by colors, with R1 the most imperiled.

Two hundred twenty-eight species of odonates are known from the northeast region, an area that is widely considered to be a "hotspot" for odonate diversity, and 130 of those species are known to occur on the Delmarva Peninsula. Seventy-nine species of odonates are included on the SGCN list

for Delaware, ranging from common species for which the northeast has high conservation responsibility, to rare species and many species that are at the edge of their ranges in the state.

Lepidoptera: Butterflies and Moths

Butterflies and Skippers

Forty-one species of butterflies and skippers are considered SGCN in Delaware.

Table 1. 27 Delaware Butterfly and Skipper SGCN

Butterflies & Skippers (41)	
Early Successional Herbaceous Butterflies	
Anatrytone logan	Delaware Skipper
Boloria bellona	Meadow Fritillary
Danaus plexippus	Monarch
Erynnis baptisiae	Wild Indigo Duskywing
Pompeius verna	Little Glassywing
Pontia protodice	Checkered White
Speyeria idalia	Regal Fritillary
Early Successional Shrubland Butterflies	
Callophrys gryneus	Juniper Hairstreak
Floodplain Forest Butterflies	
Asterocampa celtis	Hackberry Emperor
Asterocampa clyton	Tawny Emperor
Autochton cellus	Gold-banded Skipper
Libytheana carinenta	American Snout

Forest Butterflies	
Erynnis martialis	Mottled Duskywing
Feniseca tarquinius	Harvester
Polygonia progne	Gray Comma
Satyrium liparops strigosum	Striped Hairstreak
Forest Edge Butterflies	
Erynnis icelus	Dreamy Duskywing
Poanes hobomok	Hobomok Skipper
Forest Understory Butterflies	
Battus philenor	Pipevine Swallowtail
Callophrys henrici	Henry's Elfin
Celastrina neglectamajor	Appalachian Azure
Habitat Generalist Butterflies	
Speyeria aphrodite	Aphrodite Fritillary
Herbaceous Wetland Butterflies	
Boloria selene myrina	Myrina Fritillary
Euphydryas phaeton	Baltimore Checkerspot
Euphyes conspicua	Black Dash
Euphyes dion	Dion Skipper
Lethe eurydice	Eyed Brown
Lycaena hyllus	Bronze Copper
Poanes massasoit chermocki	Chermock's Mulberry Wing
Poanes massasoit massasoit	Mulberry Wing

Forested Wetland Butterflies	
Callophrys hesseli	Hessel's Hairstreak
Satyrium kingi	King's Hairstreak
Wallengrenia otho	Southern Broken-Dash
Atlides halesus	Great Purple Hairstreak
Tidal Wetland Butterflies	
Problema bulenta	Rare Skipper
Xeric Opening Butterflies	
Atrytonopsis hianna	Dusted Skipper
Callophrys augustinus	Brown Elfin
Callophrys irus	Frosted Elfin
Erynnis brizo brizo	Sleepy Duskywing
Hesperia metea	Cobweb Skipper
Hesperia sassacus	Indian Skipper

The northeast RSGCN list is dominated by two families, the skippers (family Hesperiidae) and the blues, coppers, and elfins (family Lycaenidae). Butterflies of the families Hesperiidae and Lycaenidae occur in large numbers on the regional and state SGCN lists because many species in these families are small-bodied, relatively weak fliers with very specific host plant requirements, or they have other narrow ecological specializations such as association with specific vegetation communities. In addition, the larvae of many species of Lycaenidae participate in symbiotic relationships with ants, so that both the larval host plant and suitable ant partners must be available in order for the species to thrive.

Figure 1. 6 Baltimore Checkerspot (*Euphydryas phaeton*) is a declining SGCN found in Delaware only in Piedmont wetlands.

Beginning in the 1990's, researchers have documented a steady decline in Monarch Butterfly (*Danaus plexippus*) numbers. A primary threat to the Monarch Butterfly is a decline in populations of milkweed, the primary food plant required by caterpillars. The decline in milkweed is partially due to the reduction of open habitats, but in the Midwest losses are mostly due to the dramatic increase in use of the herbicide Roundup (glyphosphate) which has been made possible by the mass-planting of genetically modified herbicide resistant corn and soy (Pleasants and Oberhauser 2012). In addition, the widespread use of systemic insecticides such as neonicotinoids within the breeding range of the Monarch poses a considerable threat, illegal logging of fir forests in Mexico has reduced wintering habitat, and extreme weather events in the eastern U.S. may be negatively impacting Monarchs.

In recognition of the decline in Monarch Butterflies, the Monarch Joint Venture (MJV) was initiated in December 2008 as a partnership of federal agencies, state agencies, non-governmental organizations, and academic programs working together to protect the Monarch and its annual, long-distance migration. Guided by the North American Monarch Conservation Plan (2008), the MJV is taking a science-based approach to addressing monarch conservation issues. The MJV

promotes Monarchs as a flagship species whose conservation will sustain habitats for pollinators and other plants and animals. For more information about MJV: http://www.monarchjointventure.org/.

Moths

The nocturnal Macrolepidoptera ("larger moths") of Delaware have been studied in recent years by Heckscher, Gonzon, and others. Still, much of our data is based on regional sources. Important recent work by Tuttle (2007), Schweitzer et al. (2011), and Wagner et al. (2011) have greatly improved the readily accessible body of knowledge on northeastern macromoth species of conservation interest. More than 1000 species of moths have been documented in Delaware, with some groups receiving greater attention than others.

The larvae of moths in the genus *Papaipema* (family Noctuidae) bore into the stems and tubers of plants and many are specific to a particular species of plant. Host specificity has resulted in many species becoming rare due to the decline of their host plant. A recent survey of Brandywine Creek State Park (New Castle County) by Heckscher and Schweitzer (unpub. data) found that the meadow Papaipema fauna was largely intact while the forest understory fauna was mostly depauparate probably due to deer over-browse, alien earthworms, and alien plant species. The family of sphinx or hawk moths (family Sphingidae) includes several well-known agricultural pests as well as several rare and declining species. Certain hawk moths are diurnally active and many species can be important pollinators of flowers with long, tubular corollas.

Giant silkworm moths (family Saturniidae) are among the most colorful and spectacular species of Lepidoptera in the world and several of the largest and most beautiful species have recently declined across the Northeast. These declines have been anecdotally attributed to increased spraying of chemicals for mosquito and other pest control and to increased anthropogenic light pollution, which disrupts the normal nocturnal flight patterns of these insects. The Buck Moth (*Hemileuca maia*) is a diurnal silkworm moth closely associated with Scrub Oak that primarily occurs in serpentine barrens where this oak often dominates the understory. The Buck Moth has experienced notable declines in the northeast due to habitat loss.

The *Catocala* (underwing) moths are among the most impressive and most speciose Noctuidae groups in eastern North America. Many species are designated Delaware SGCN due to their dependency on specific host plants that may be uncommon. For example, several species are dependent upon shagbark hickory (*Carya ovata*) which is uncommon in the state outside the Red Clay Creek valley. Other reasons for rarity in this moth group include Delaware's position at the northern or southern edge of the natural range of several species. Xeric or semi-xeric sand ridges

and forests in Sussex County are scattered but highly threatened by development. These forests are often hickory-rich providing important concentrations of Coastal Plain *Catocala* populations. Similarly, mesic hardwood forests of the Piedmont often support a mix of several hickory species providing a rich *Catocala* fauna including some regionally uncommon species. Salicaceae feeding species may be threatened by sea-level rise including *Catocala carissima*.

Summerville and Crist (2002) and Summerville (2004) in the US, along with Pavlikova and Konvicka (2011) in Europe, have shown that classification of moth functional groups by life form of the larval food source is useful in predicting responses to habitat change. The ecological groups below classify Delaware's SGCN species by broad habitat type and by larval host plant life form.

Table 1. 28 Delaware Moth SGCN

Moths (103)	
Dune Forb-feeding Moths	
Drasteria graphica	Graphic Moth
Melitara prodenialis	Eastern Cactus-boring Moth
Schinia spinosae	A Noctuid Moth
Sympistis perscripta	A Noctuid Moth
Forest Forb-feeding Moths	
Hadena ectypa	A Noctuid Moth
Forest Litter-feeding Moths	
Macrochilo louisiana	Louisiana Macrochilo
Forest Tree Canopy-feeding Moths	
Catocala cerogama	Yellow Banded Underwing
Catocala dejecta	Dejected Underwing
Catocala flebilis	Mournful Underwing
Catocala habilis	Habilis Underwing

Catocala innubens	The Betrothed Underwing
Catocala insolabilis	Inconsolable Underwing
Catocala lacrymosa	Tearful Underwing
Catocala maestosa	Sad Underwing
Catocala marmorata	Marbled Underwing
Catocala minuta	Little Underwing
Catocala nebulosa	Clouded Underwing
Catocala obscura	Obscure Underwing
Catocala residua	Residua Underwing
Catocala ulalume	An Underwing Moth
Catocala umbrosa	An Underwing Moth
Catocala unijuga	Once-married Underwing
Chloropteryx tepperaria	Angle Winged Emerald Moth
Lapara coniferarum	Southern Pine Sphinx
Lophocampa caryae	Hickory Tussock Moth
Sphinx franckii	Franck's Sphinx
Tolype notialis	Small Tolype Moth
Zale metata	A Noctuid Moth
Zale metatoides	Washed-out Zale Moth
Zale squamularis	A Noctuid Moth
Forest Tree-feeding Moths	
Acronicta exilis	Exiled Dagger Moth
Acronicta increta	Southern Oak Dagger Moth
Acronicta lithospila	Streaked Dagger Moth

Amorpha juglandis	Walnut Sphinx
Calyptra canadensis	Canadian Owlet
Caripeta aretaria	A Geometrid Moth
Ceratomia undulosa	Waved Sphinx
Copivaleria grotei	Grote's Sallow
Eacles imperialis	Imperial Moth
Hemileuca maia maia	Eastern Buckmoth
Heterocampa astarte	A Notodontid Moth
Manduca jasminearum	Ash Sphinx
Papaipema furcata	Ash Borer Moth
Papaipema marginidens	A Borer Moth
Forest Understory-feeding Moths	
Acronicta rubricoma	Ruddy Dagger Moth
Amphion floridensis	Nessus Sphinx
Catocala alabamae	Alabama Underwing
Catocala antinympha	Sweetfern Underwing
Catocala mira	Wonderful Underwing
Catocala praeclara	Praeclara Underwing
Deidamia inscriptum	Lettered Sphinx
Dolba hyloeus	Pawpaw Sphinx
Haploa colona	Colona Moth
Manduca rustica	Rustic Sphinx
Paonias astylus	Huckleberry Sphinx

Papaipema araliae	Aralia Shoot Borer Moth
Papaipema astuta	Yellow Stoneroot Borer
Papaipema duplicatus	Dark Stoneroot Borer Moth
Papaipema inquaesita	Sensitive Fern Borer Moth
Papaipema pterisii	Bracken Borer Moth
Papaipema rutila	Mayapple Borer Moth
Papaipema speciosissima	Osmunda Borer Moth
Papaipema stenocelis	Chain Fern Borer Moth
Paratrea plebeja	Plebian Sphinx
Pero ancetaria	Hübner's Pero
Sphinx chersis	Great Ash Sphinx
Synanthedon castaneae	Chestnut Clearwing Moth
Forest/meadow-feeding Moths	
Agnorisma bollii	A Noctuid Moth
Freshwater Wetland Forb-feeding Moths	
Bellura gortynoides	A Noctuid Moth
Capsula subflava	A Noctuid Moth
Exyra fax	Pitcher Plant Moth
Papaipema appassionata	Pitcher Plant Borer Moth
Papaipema lysimachiae	Loosestrife Borer Moth
Parapamea buffaloensis	Buffalo Moth
Tarache delecta	A Noctuid Moth
Freshwater Wetland Tree-feeding Moths	
Acronicta connecta	Connected Dagger Moth

Catocala carissima	An Underwing Moth
Catocala parta	Mother Underwing
Cerura scitiscripta	Black-Etched Prominent
Darapsa versicolor	Hydrangea Sphinx
Gluphisia lintneri	A Notodontid Moth
Iridopsis pergracilis	A Geometrid Moth
Orgyia detrita	A Tussock Moth
Freshwater wetland woody plant-feeding moths	
Argyrostrotis quadrifilaris	Four-lined Chocolate Moth
Xestia dilucida	A Noctuid Moth
Lichen-feeding moth	
Cisthene kentuckiensis	Kentucky Lichen Moth
Cisthene tenuifascia	Thin-Banded Lichen Moth
Nigetia formosalis	Thin-winged Owlet Moth

Beetles

Tiger Beetles

Tiger beetles are a group of highly active, predatory beetles that have been variously classified as either a subfamily (Cicindelinae) within the larger Family Carabidae, or a separate Family Cicindelidae. The Northeast RSGCN list includes 11 tiger beetle taxa, encompassing over half of the Northeast tiger beetle fauna. Several tiger beetle species remain common throughout the Northeast, including the six-spotted tiger beetle (*Cicindela sexguttata*), bronzed tiger beetle (*Cicindela repanda*), and punctate tiger beetle (*Cicindela punctulata*), which can be found in many urban and suburban areas.

Sympatric tiger beetle species (those that occur together in the same habitat) and their larvae are often closely associated with particular microhabitats, especially exposures of different soil types, such as sand or clay (Schultz 1989). Distinct thermal microhabitat preferences have also been described for oviposition (Hoback et al. 2000) and adult activity (Schultz 1998). These specializations make some species susceptible to habitat degradation that alters or eliminates their necessary microhabitats.

Several tiger beetle species are known to be in decline range-wide. These include *Cicindela patruela*, a pine barrens and ridge-top barrens species that has been lost from many historical sites in the Northeast states, as well as *Cicindela lepida*, a species that was formerly associated with sand dunes and other open sandy areas across the central and eastern states. Knisely et al. (2014) reviews the conservation status of U.S. tiger beetle species.

Certain guilds of tiger beetles are known to be at elevated risk for extirpation or even extinction. Population declines have been documented in many species of tiger beetles associated with ocean beaches, including two Northeast RSGCN, the federally listed *Cicindela dorsalis dorsalis* and its southern counterpart *Cicindela dorsalis media*. Beach-nesting tiger beetles have been found to be sensitive to compaction of sands resulting from human disturbance (Cornelisse 2009), a factor that has probably contributed to the widespread decline of *Cicindela dorsalis*. Whereas other beach-dependent species such as piping plover (a shorebird) leave Delaware's beaches during the winter, tiger beetles spend their entire lives in this habitat and are vulnerable to vehicular use at all seasons. Cicindela dorsalis dorsalis was federally listed as Threatened in 1990, with a Recovery Plan drafted in 1994 (USFWS 1994).

Figure 1. 7 The federally Threatened Eastern Beach Tiger Beetle (*Cicindela dorsalis dorsalis*) once occurred in Delaware but is now extirpated from the state. Its sandy beach habitats have been heavily impacted by destruction and disturbance of natural beach habitat from shoreline development, beach stabilization, and high levels of recreational use. Photo: Mike Drummond / USFWS

One of the tiger beetles on the RSGCN list is primarily nocturnal or crepuscular and thus is often overlooked in diurnal beetle surveys. *Cicindela unipunctata* was once thought to be uncommon to rare throughout its range, but pitfall trapping studies in the New Jersey Pine Barrens demonstrated that this species can occur in large numbers at sites where it is not observed during daylight hours (Boyd 1985).

Delaware's SGCN tiger beetle list could potentially be expanded, and populations of conservation importance located, with additional survey effort. For example, the tiny pine barrens specialist *Cicindela abdominalis* is found at relatively few sites across the entire Northeast, but has large populations in the New Jersey Pine Barrens and occurs on the Maryland portion of Delmarva. This

species has been looked for by K. Heckscher in Sussex County, without success, but further inventory is warranted.

Table 1. 29 Delaware Tiger Beetle SGCN

Tiger Beetles (14)	
Cicindela dorsalis dorsalis	Eastern Beach Tiger Beetle
Cicindela dorsalis media	White Tiger Beetle
Cicindela duodecimguttata	Twelve-spotted Tiger Beetle
Cicindela formosa generosa	Big Sand Tiger Beetle
Cicindela hirticollis	Hairy-necked Tiger Beetle
Cicindela lepida	Ghost Tiger Beetle
Cicindela marginata	Margined Tiger Beetle
Cicindela patruela	Northern Barrens Tiger Beetle
Cicindela patruela consentanea	New Jersey Pine Barrens Tiger Beetle
Cicindela purpurea	Cow Path Tiger Beetle
Cicindela rufiventris	Eastern Red-bellied Tiger Beetle
Cicindela scutellaris	Festive Tiger Beetle
Cicindela unipunctata	One-spotted Tiger Beetle
Tetracha virginica	Virginia Big-headed Tiger Beetle

Fireflies

The study of fireflies has a rich history in Delaware, thanks largely to pioneering work by Frank A. McDermott, a chemist who spent his retirement studying this family and in the process became one of only a few North American experts on the taxon. McDermott discovered a new firefly species near the town of Bethany Beach in 1946 and named it *Photuris bethaniensis*, the Bethany Beach

Firefly (McDermott 1953). So far, this species has not been found outside the state of Delaware and is currently recognized as Delaware's only endemic species. Another Delaware species, *Photuris mysticalampas*, was discovered and described by Christopher M. Heckscher in 2013 (Heckscher 2013). Like *Photuris bethaniensis*, this species has not been found outside of Delaware; however, it's assumed it occurs in Maryland as much suitable habitat can be found in that state. Due to its history as an epicenter for the study of North American fireflies, the distribution and abundance of many Delaware species are fairly well known. Consequently, Delaware is the only Northeastern state to have evaluated the conservation status of its fireflies.

Three genera of nocturnal bioluminescent fireflies are widespread in North America: *Photuris, Photinus*, and *Pyractomena*. Of the three, the *Photuris* are the best understood in Delaware, largely because of the work of McDermott and Heckscher, while elsewhere more is known about the distribution and abundance of *Photinus* than *Photuris*. From the collections of McDermott, *Pyractomena dispersa* was described from the wetlands of the Beaver Valley of the upper Brandywine watershed (Green 1957). In addition, *Photuris bethaniensis* and *Photuris mysticalampas* were first described from Bethany Beach and Phillips Landing, respectively. *Photuris pennsylvanica* is thought to have been first collected and described from the marshes of Wilmington, Delaware (McDermott 1967). Thus, four species have their type locality in Delaware: *Pyractomena dispersa*, *Photuris bethaniensis, Photuris mysticalampas, Photuris pennsylvanica.*

Most fireflies are associated with wetlands, as the soft-bodied larvae, better known as glowworms, might otherwise be susceptible to dessication. Soil chemistry, microclimate (e.g., humidity, temperature), or prey items, might also limit the distribution of some species. Due to their affiliation with various threatened wetland types, several species are of high conservation concern. *Photuris bethaniensis* is restricted to rare and threatened interdunal wetlands that occur within the backdunes along Delaware's Atlantic coast (Heckscher and Bartlett 2004). Interdunal swales are threatened by sea-level rise, coastal development, and invasive plant species. *Photuris mysticalampas* is associated with forested peatland floodplains of high ecological quality in Sussex County (Heckscher 2013). *Photuris pennsylvanica* is associated with freshwater emergent and shrub wetlands that are usually tidally influenced (Heckscher 2010). All tidal freshwater wetlands are becoming increasingly threatened by sea-level rise. *Photuris salina* and *Pyractomena ecostata* are both restricted to salt and brackish coastal marshes and are therefore likely threatened by sea-level rise, adulticides used for mosquito control, and the spread of the invasive *Phragmites australis* (Heckscher 2010; Heckscher and Lloyd, in press). All fireflies are suspected of being sensitive to pesticide application including those that occur in urban areas. In general, many species seem to be in regional decline especially representatives of the genus *Pyractomena* (Heckscher and Lloyd, in press).

Table 1. 30 Delaware Firefly SGCN

Fireflies (13)	
Photuris bethaniensis	Bethany Beach Firefly
Photuris pennsylvanica	A Firefly
Photinus floridanus	A Firefly
Photinus ignitus	A Firefly
Photuris cinctipennis	A Firefly
Photuris frontalis	A Firefly
Photuris hebes	A Firefly
Photuris pyralomimus	A Firefly
Photuris tremulans	A Firefly
Pyractomena dispersa	A Firefly
Forest Fireflies	
Photuris mysticalampas	A Firefly
Tidal Marsh Fireflies	
Photuris salina	A Firefly
Pyractomena ecostata	A Firefly

Water Beetles

Water beetles reach high levels of diversity in isolated wetlands, especially vernal pools and Coastal Plain seasonal ponds. With a high density of these habitat types, Delaware, and the Delmarva Peninsula as a whole, are likely a "hotspot" for water beetle diversity. The absence of fish is a major factor influencing community composition and abundance of water beetles in pond habitats (Fairchild et al. 2000).

The Seth Forest water scavenger beetle (*Hydrochus spangleri*), a globally critically imperiled beetle known from a single wetland in Maryland since the 1970s, was subsequently found to inhabit a handful of similar sites in the northern part of the Delmarva peninsula, including New Castle County, Delaware (Steiner et al. 2003). Surveys by McIntosh and Short (2012) revealed the continuing occurrence of the species in two small and densely forested vernal pools in northern Delaware.

The primary threat to water beetles is residential and commercial development of the unprotected, isolated wetlands in which they occur, as well as the surrounding forest matrix. In addition, climate change may affect these species due to their reliance on a shallow, ephemeral wetland habitat combined with apparently very limited dispersal ability. Many species are attracted to lights, so light pollution may be an additional threat for populations in fragmented habitats near residential and commercial areas.

Table 1. 31 Delaware Freshwater Beetle SGCN

Freshwater Beetles	
Agabetes acuductus	A Predaceous Diving Beetle
Helocombus bifidus	A Water-scavenger Beetle
Hoperius planatus	A Predaceous Diving Beetle
Hydrochus spangleri	Seth Forest Water Scavenger Beetle

Other Beetles

Table 1. 32 Delaware Other Beetle SGCN

Other Beetles	
Lucanus elaphus	Giant Stag Beetle
Nicrophorus americanus	American Burying Beetle

Hymenoptera: Bees and Wasps

Considerable concern has been expressed about the conservation status and population trends of native pollinators across North America. Available evidence indicates that certain pollinator species have been declining in the U.S., and flower-visiting insects account for 50% of all known insect extinctions (NRCS 2007). Reduced pollinator populations can result in decreased pollination of plant species that require pollinators for fertilization and reproduction.

Declines in pollinator populations are poorly understood in most cases, with potential contributing factors including intensification of agricultural practices, use of certain pesticides, and habitat loss and degradation. Some bumblebees, particularly *Bombus affinis* in the east, have experienced declines as a result of the apparent spread of parasites accidentally introduced from European bees used in hothouse tomato production. Climate change is also expected to pose additional challenges to pollinator populations, including decoupling of plant-pollinator interactions when plants and pollinators respond differently to climate cues.

Most pollinator species are invertebrates, mostly insects. Major pollinator groups in the Northeast include social and solitary bees, certain groups of solitary wasps, as well as many flies, beetles, butterflies, and moths. The Xerces Society has published a *Red List of Native Bees in Decline* (Xerces Society 2014). The Heinz Center (2013) has prepared guidance for incorporating information about the conservation of animal pollinators into Wildlife Action Plans.

Limited data on Delaware's native bee fauna is available as a result of survey work completed by the Delaware Department of Agriculture, Plant Industries Section during the early 2000s. Additional records from museum specimens and the literature were compiled by J. Ascher at the American Museum of Natural History. Parasitic bee groups, including the cleptoparasitic cuckoo bees (*Nomada*) and the nest parasite cuckoo bumble bees (*Bombus* subgenus *Psithyrus*) are now considered especially imperiled due to presumed baseline rarity and declines of their host species.

Although probably not significant pollinators, two Pompilidae (spider wasp) species occur on the SGCN list: *Psorthaspis sanguinea* and *P. mariae*. Both species are at or near the northern limit of their distribution and both appear to be dependent on specific edaphic features associated with xeric forests (Heckscher 2014). *Psorthaspis sanguinea* is known from Cape Henlopen State Park and this occurrence represents a disjunct population from the North Carolina coast and consequently the only known location in the northeast (Heckscher 2014).

Table 1. 33 Delaware Bee and Wasp SGCN

Bees & Wasps (11)

Bumble Bees	
Bombus affinis	Rusty-patched Bumble Bee
Bombus ashtoni	Ashton's Cuckoo Bumble Bee
Bombus auricomus	Black and Gold Bumble Bee
Bombus fraternus	Southern Plains Bumble Bee
Bombus pensylvanicus	American Bumble Bee
Bombus vagans	Half-black Bumble Bee
Bombus variabilis	Variable Cuckoo Bumble Bee
Ground-nesting Bees and Wasps	
Colletes aestivalis	A Cellophane Bee
Lasioglossum marinum	A Sweat Bee
Lasioglossum nymphale	A Sweat Bee
Nomada rubicunda	A Cuckoo Bee

Aquatic Macroinvertebrate Insects

Delaware's aquatic macroinvertebrates have been surveyed extensively during water quality monitoring efforts, however in many cases these immature stages are not identified to species level. The Delaware Department of Natural Resources and Environmental Control assesses the water quality in its non-tidal, perennial streams using standard physical, chemical, and biological criteria (Barbour et al. 1999) on a regional basis: Piedmont and Coastal Plain on alternating years. Semiquantitative macroinvertebrate samples are taken during fall low-flow conditions using a D-net (approximately 6 m2 per sample), and subsampled to a 200 count.

Limited species-level survey work on adult caddisflies (Trichoptera) and stoneflies (Plecoptera) was conducted in the early 1980s (Lake 1980, 1984) in Delaware and these published records form the basis for the state lists for those orders.

Aquatic macroinvertebrates have also been separated ecologically into lotic-erosional (running water riffles), lotic-depositional (running water pools and margins), lentic-limnetic (standing water), lentic-littoral (standing water, shallow shore areas), lentic-profundal (standing water, basin), and beach zone groups (Wallace and Anderson, 1996).

Several species of hydropsychid caddisflies are some of the most imperiled freshwater invertebrates in Delaware. This family consists of mostly lotic-erosional species (Merritt and Cummins 1996).

Table 1. 34 Delaware Freshwater Aquatic Insect SGCN

Freshwater Aquatic Insects (12)	
Agarodes libalis	Spring-loving Psiloneuran Caddisfly
Anisocentropus pyraloides	A Caddisfly
Beraea fontana	A Caddisfly
Beraea nigritta	A Caddisfly
Cheumatopsyche virginica	A Caddisfly
Cheumatopsyche wabasha	A Caddisfly
Helicopsyche borealis	A Caddisfly
Hydropsyche hoffmani	A Caddisfly
Hydropsyche impula	A Caddisfly
Hydropsyche opthalmica	A Caddisfly
Neophylax delicatus	A Caddisfly
Polycentropus chenoides	A Caddisfly
Ostrocerca prolongata	Bent Forestfly

Mollusks

Freshwater Mussels

The ecology and habitat associations of North American freshwater mussels were recently reviewed by Haag (2012). As some of the least mobile and longest-living freshwater aquatic organisms, mussels provide a lens to evaluate long-term trends and conditions (Grabarkiewicz and Davis 2008). As filter-feeding bivalves, they are important links in the food chain, filtering bacteria and suspended materials from the water. Their reproduction is complex, relying on species-specific host fish for successful completion of the life cycle.

The RSGCN list for the northeastern states includes 23 freshwater mussel species, including seven taxa that are high regional responsibility as well as high or very high conservation concern. Six of these species are or were present historically in Delaware: dwarf wedgemussel (*Alasmidonta heterodon*), brook floater (*Alasmidonta varicosa*), northern lance (*Elliptio fisheriana*), yellow lampmussel (*Lampsilis cariosa*), tidewater mucket (*Leptodea ochracea*), Eastern pondmussel (*Ligumia nasuta*), triangle floater (*Alasmidonta undulata*), and alewife floater (*Anodonta implicata*).

Freshwater mussels are highly imperiled in Delaware. Of the thirteen species known from the state, eleven are considered SGCN. Six species are listed on the Delaware Endangered Species List and four of these are extirpated or historical in the state.

Dwarf wedgemussel (Alasmidonta heterodon) was Federally listed as Endangered in 1993 (55 FR 9447; U.S. Fish and Wildlife Service 1993).

Table 1. 35 Delaware Freshwater Mussel SGCN

Freshwater Mussels (11)	
Alasmidonta heterodon	Dwarf Wedgemussel
Alasmidonta undulata	Triangle Floater
Alasmidonta varicosa	Brook Floater
Anodonta implicata	Alewife Floater
Elliptio complanata	Eastern Elliptio

Elliptio fisheriana	Northern Lance
Lampsilis cariosa	Yellow Lampmussel
Lampsilis radiata	Eastern Lampmussel
Leptodea ochracea	Tidewater Mucket
Ligumia nasuta	Eastern Pondmussel
Strophitus undulatus	Creeper

Primarily Riverine Species

A few of the Delaware's freshwater mussel species are closely associated with riverine habitats, including brook floater (*Alasmidonta varicosa*), dwarf wedgemussel (*Alasmidonta heterodon*), and creeper (*Strophitus undulatus*). These four species are long-term brooders, requiring suitable spawning conditions in the summer and fall, and access to host fish in the spring and early summer. Host fish include darter, sculpin, and minnows. Dwarf wedgemussel occurs in small rivers, major tributaries, and on the mainstem near islands on low gradient reaches (Cole et al. 2008).

Semi-riverine Species

These species include alewife floater (*Anodonta implicata*), triangle floater (*Alasmidonta undulata*), yellow lampmussel (*Lampsilis cariosa*), and Eastern elliptio (*Elliptio complanata*). They are found in a variety of habitats, including small streams, large rivers, and lakes. Yellow lampmussel and eastern elliptio are associated with larger-bodied, mobile host fish. Alewife floater is also associated with highly mobile host fish, possibly including American shad and blueback herring, in addition to alewife (Nedeau et al. 2000). Because their host fish are highly mobile, species recruitment is directly related to longitudinal connectivity. Alewife floater populations have expanded in direct response to the installation of fish passage (Smith 1985).

Freshwater mussels have declined due to the cumulative impact of numerous threats, including dams, pollution, and declines in host fish populations. Future concerns include potential water temperature and oxygenation effects of climate change, as well as physical impacts of floods and increased severe precipitation events. Some species will be subject to increased salinities from saltwater intrusion related to sea-level rise.

In 2007, the Partnership for the Delaware Estuary (PDE) launched the **Freshwater Mussel Recovery Program** (FMRP), aimed to conserve and restore native freshwater mussels in the Delaware Estuary. The FMRP is part of PDE's watershed-based shellfish restoration strategy. DNREC Division of Fish and Wildlife has conduced freshwater mussel surveys, finding the state's highest species diversity in the Chesapeake drainages of Deep Creek (Nanticoke River watershed) and the Choptank River (Heckscher and Bennett 1999).

Land Snails

Table 1. 36 Delaware Land Snail SGCN

Land Snails (21)	
Anguispira alternata	Flamed Tigersnail
Anguispira fergusoni	Coastal-plain Tigersnail
Carychium exiguum	Obese Thorn
Catinella hubrichti	Snowhill Ambersnail
Discus catskillensis	Angular Disc
Euconulus dentatus	Toothed Hive
Gastrocopta armifera	Armed Snaggletooth
Glyphyalinia picea	Rust Glyph
Haplotrema concavum	Gray-foot Lancetooth
Oxyloma effusum	Coastal-plain Ambersnail
Philomycus flexuolaris	Winding Mantleslug
Punctum vitreum	Glass Spot
Pupoides albilabris	White-lip Dagger
Stenotrema hirsutum	Hairy Slitmouth

Triodopsis tridentata	Northern Threetooth
Ventridens intertextus	Pyramid Dome
Vertigo ovata	Ovate Vertigo
Vertigo pygmaea	Crested Vertigo
Vertigo teskeyae	Swamp Vertigo
Vertigo tridentata	Honey Vertigo
Zonitoides nitidus	Black Gloss

From 1997 to 2001 then Delaware Museum of Natural History Curator of Mollusks Dr. Tim Pearce conducted research (funded by the National Science Foundation) on land snails of Delmarva, compiling an unpublished preliminary list of 75 species for Delaware (Pearce pers. comm.)

Land snail species richness is significantly higher in high base sites (Nekola 2005) and it is likely that Delaware land snails are disproportionately diverse in basic mesic forests, as was the case in the coastal Carolinas in Nekola's study. Species within a region also cluster at the landscape scale according to habitat type, soil surface architecture, geography, moisture levels and presence of anthropogenic disturbance (Nekola 2003).

Freshwater Snails

Table 1. 37 Delaware Freshwater Snail SGCN

Freshwater Snails (5)	
Gyraulus deflectu	Flexed Gyro
Littoridinops tenuipes	Henscomb Hydrobe
Physa carolinae	Carolina Physa
Pomatiopsis lapidaria	Slender Walker
Promenetus exacuous	Keeled Promenetus

21 species of freshwater gastropods are known from Delaware based on work by Dillon et al. (2013).

Dillon et al. (2013) visited the Dover laboratories of DNREC in January of 2013 and reviewed macrobenthic samples from three years: 2006 (Piedmont), 2010 (Coastal Plain), and 2011 (Piedmont). Approximately 40 – 50 sites were sampled each of these years, yielding a total of 198 freshwater gastropod records. Supplementing this were specimens from the following institutions: US National Museum in Washington, the Academy of Natural Sciences of Philadephia, the Carnegie Museum of Natural History in Pittsburgh, and the Delaware Museum of Natural History in Wilmington and personal collections made by the authors within Delaware.

Of the 21 species known from the state, 5 were included as SGCN in this revision. *Physa carolinae*, a southern species reaching the northern edge of its known distribution in Delaware, was recently described (Wethington et al. 2009).

Estuarine and Marine Invertebrates

Benthic habitats of the Mid-Atlantic Bight contain over 2000 species of invertebrates such as marine worms, sponges, shrimp, crab, clams, scallops, snails, sea stars, and anemones (MARCO).

A current effort to inventory and develop a digital field guide to zooplankton of Delaware Bay is being conducted by University of Delaware researcher Jonathan Cohen.

The horseshoe crab is perhaps Delaware's most iconic invertebrate. Horseshoe crabs (*Limulus polyphemus*) concentrate in the Delaware Bay to spawn on the sandy beaches fringing its shorelines. The vast quantities of eggs the crabs deposit on these beaches serve as an important food resource for migrating shorebirds. Horseshoe crab population indices in the Delaware Bay declined dramatically (by approximately 90%) from the early 1990s to the mid-2000s (Niles 2009). While the Atlantic States Marine Fisheries Commission (ASMFC) has worked via an adaptive management framework to set harvest limits on bait harvest of horseshoe crabs in Delaware Bay for a number of years, these limits (generally an annually-set male-only harvest quota apportioned by state) are resulting so far in only modest increases in previously depleted horseshoe crab populations, which is perhaps unsurprising due to the long generation time of the species. While some evidence of horseshoe crab increase is available, the greatly shifted baseline from which current populations are recovering makes restoring the species to historic population levels difficult in the near-term.

Blue crabs (*Callinectes sapidus*) are a ubiquitous, commercially-important species found throughout the waters of the estuary. Oysters (*Crassostrea virginica*) play an important role in the bay, both as

filter-feeders, and because oyster reefs provide essential habitat for numerous other estuarine species.

The filtration capacity of ribbed mussels (*Geukensia demissa*) in Delaware Bay tidal marshes has been estimated to exceed that of oysters and other native bivalves. Ribbed mussels are foundation species in salt marshes, helping the marsh edge resist erosion and generating waste accumulations that help the marsh build elevation.

Table 1. 38 Delaware Estuarine and Marine Invertebrate SGCN

Estuarine / Marine Invertebrates (7)	
Busycon carica	Knobbed Whelk
Busycotypus canaliculatus	Channeled Whelk
Callinectes sapidus	Blue Crab
Crassostrea virginica	American Oyster
Geukensia demissa	Ribbed Mussel
Homarus americanus	American Lobster
Limulus polyphemus	Horseshoe Crab

Update and Revision of Delaware's Wildlife Species of Greatest Conservation Need List

As part of the federal requirement to address conservation of the broad array of wildlife in Delaware, 459 Species of Greatest Conservation Need (SGCN) were identified in Delaware's 2007 Wildlife Action Plan. Beginning in March 2014, the criteria and SGCN list were re-evaluated resulting in a list of 670 species and subspecies of mammals, birds, amphibians, reptiles, fishes and invertebrates for the 2015 Wildlife Action Plan Revision.

Summary of SGCN List Changes since 2007

Because of the availability of more recent and complete data for many taxa, rather than reevaluate the status of each of the 2007 GCN species for the 2015 revision, the 2015 list was created anew using a slightly different set of inclusion criteria, followed by screening by species experts using a simple decision tree. The results of this exercise were then compared to the SGCN list from 2007.

After screening using the decision framework shown in Box 1.2 to remove several accidental and extralimital taxa, the final SGCN list contains 670 taxa. The taxonomic makeup of the SGCN list is shown in Table 1.39 below.

Table 1. 39 Taxonomic Distribution of SGCN

Taxonomic Group	Species of Greatest Conservation Need
Insects	291
Birds	183
Bony Fishes	51
Sharks and Rays	32

Snails	28
Mammals	24
Amphibians	19
Snakes and Lizards	14
Turtles	11
Freshwater Mussels	11
Other Invertebrates	5
Lampreys	2
TOTAL	**671**

Overall, the 2015 GCN list reflects a comprehensive approach to identifying of species of conservation concern across many taxa, including many representatives of historically underrepresented taxonomic groups.

Additions since 2007

The updated process resulted in the addition of 237 previously unlisted taxa and a net addition of 212 taxa to the SGCN list. These additions are the result of several factors. The primary driver is the inclusion in the 2015 list of a regional perspective. Incorporating Northeast Regional Species of Greatest Conservation Need (vertebrates) and Regional Odonates of Conservation Concern as listing criteria generated a number of Delaware SGCN that were not previously listed.

In addition, a much larger number of marine fish and sharks are included in the 2015 list, primarily because all ASMFC Managed species known or likely to occur offshore of Delaware or within Delaware waters were included. A number of invertebrate species were also added, based on work completed in Delaware since 2007 that has led to S-ranking of additional species, especially moths, odonates, and caddisflies.

Removals since 2007

Sixteen species included as SGCN in the 2007 Delaware Wildlife Action Plan did not meet the 2015 SGCN inclusion criteria, and thus were removed from the Draft SGCN list. An additional 3 taxa that were included in the 2007 WAP as both the full species and a named subspecies were edited to remove erroneous taxonomic duplicates. One species was removed because its presence on the 2007 SGCN list was based on an erroneous record and the species does not occur in Delaware. These 20 species and the reasons for their removal are presented in Table 1.40 below.

Table 1. 40 SGCN Not Meeting 2015 Criteria

Group	Scientific Name	Common Name	Global Rank	State Rank	2007 SGCN Tier	Reason Removed
Birds	*Accipiter cooperii*	Cooper's Hawk	G5	S3B	Tier 1	No longer meets Criterion #4 (S Rank) due to rank change
Birds	*Anas clypeata*	Northern Shoveler	G5	SHB, S4N	Tier 2	Decision Tree #3, rare breeding attempts outside of core range.
Birds	*Charadrius wilsonia*	Wilson's Plover	G5	SNA	Tier 2	Decision Tree #5 (very rare or casual visitor)
Birds	*Coragyps atratus*	Black Vulture	G5	S3B	Tier 2	No longer meets Criterion #4 (S Rank) due to rank change
Birds	*Coturnicops noveboracensis*	Yellow Rail	G4	SNA	Tier 2	Decision Tree #5 (very rare or casual visitor)
Birds	*Fulica Americana*	American Coot	G5	S1B, S4N	Tier 2	Decision Tree #3, rare breeding attempts outside of core range.
Birds	*Haliaeetus leucocephalus*	Bald Eagle	G5	S3B, S4N	Tier 1	No longer meets Criteria #1 (Federal listing), #2 (State Endangered), or #4 (S Rank) due to status and rank changes

Birds	*Hydrocoloeus minutus*	Little Gull	G5	SNA	Tier 2	Decision Tree #5 (very rare or casual visitor)
Birds	*Pandion haliaetus*	Osprey	G5	S4B	Tier 1	Original listing justification "Sensitive / Significant Population – Indicator Species" no longer considered valid criterion
Birds	*Pelecanus erythrorhynchos*	American White Pelican	G4	SNA	Tier 2	Decision Tree #5 (very rare or casual visitor)
Birds	*Rhodostethia rosea*	Ross's Gull	G3G4	SNA	Tier 2	Decision Tree #5 (very rare or casual visitor)
Birds	*Strix varia*	Barred Owl	G5	S3	Tier 2	No longer meets Criterion #4 (S Rank) due to rank change
Fishes	*Pristis pectinata*	Smalltooth Sawfish	G1G3	SNR	Tier 1	No valid Delaware records
Fishes	*Ameiurus natalis*	Yellow Bullhead	G5	S3S4	Tier 1	Original listing justification "Sensitive / Significant Population – Restricted Range" no longer considered valid criterion
Insects	*Amblyscirtes aesculapius*	Lace-winged Roadside-Skipper	G3G4	SNR	Tier 2	Decision Tree #5 (very rare or casual visitor)
Insects	*Amblyscirtes carolina*	Carolina Roadside-Skipper	G3G4	SNR	Tier 2	Decision Tree #5 (very rare or casual visitor)
Insects	*Boloria selene*	Silver-bordered Fritillary	G5	S1	Tier 2	Full species removed, subspecies *myrina* retained

Insects	*Catocala palaeogama*	Oldwife Underwing	G5	S3	Tier 2	No longer meets Criterion #4 (S Rank) due to rank change
Insects	*Celithemis ornata*	Banded Pennant	G5	S2	Tier 2	Record of species in Delaware is erroneous.
Insects	*Drasteria graphica atlantica*	Atlantic graphic moth	GNR	S1	Tier 2	Subspecies *atlantica* removed, full species retained.
Insects	*Ladona deplanata*	Blue Corporal	G5	S2	Tier 2	No longer meets Criterion #4 (S Rank) due to pending S-rank change
Insects	*Satyrium liparops*	Striped Hairstreak	G5	S1	Tier 2	Full species removed, subspecies *strigosum* retained
Insects	*Sympetrum ambiguum*	Blue-faced Meadowhawk	G5	S1	Tier 2	No longer meets Criterion #4 (S Rank) due to pending S-rank change
Mammals	*Canis latrans*	Coyote	G5	SU	Tier 2	Now considered a non-native species by Delaware Division of Fish and Wildlife
Reptiles	*Pituophis melanoleucus*	Pinesnake	G4	SNA	Tier 2	No valid Delaware records

SGCN Selection Process

A multi-step system was used to generate and evaluate species for GCN status. The data sources in Table 1.41 were used in conjunction with criteria shown in Box 1.1 (Figure 1.5) below to generate the draft list via a database query process. This list was then screened using the decision framework shown in Box 1.2 (Figure 1.6) below. Additional sources of data, including but not limited to those shown in Table 1.41 were used to help ensure completeness of the list.

Table 1. 41 Additional Data Sources Reviewed to Generate SGCN Candidates

Data Source	Date of Last Revision
Delaware Elements List from Biotics Database	May 2014
Regional Species of Greatest Conservation Need (RSGCN) List for the Northeast States	2013
Delaware Endangered Species List	July 2013
Federal Endangered, Threatened, Candidate Species	May 2014
IUCN Red List	May 2014
Northeast Odonate Conservation Status Assessment	2014
Atlantic States Marine Fisheries Commission Managed Species	2014
NOAA NMFS Species of Concern	Nov 2013
American Fisheries Society Freshwater and Diadromous Fishes at Risk of Extinction	2008
Bird Conservation Region (BCR) 29 – Piedmont Priority Species	2014
Bird Conservation Region (BCR) 30 – Atlantic Coastal Plain Priority Species	2008
NEPARC Northeast Amphibian and Reptile Species of Regional Responsibility and Conservation Concern	2010

Data Source	Date of Last Revision
Partners in Flight Databases	2013
North Atlantic Regional Shorebird Plan	n.d.
North American Waterfowl Management Plan	2012
U.S. Shorebird Conservation Plan	2000
Population Estimates of North American shorebirds (Andres et al 2012)	2012
State of the Birds Report 2014	2014
Xerces Society Red List of Aquatic Invertebrates	n.d.
Xerces Society Red List of Bees	n.d.
Xerces Society Red List of Butterflies and Moths	n.d.
US Fish and Wildlife Species of Conservation Concern	2008
Sea Duck Joint Venture Strategic Plan 2014-2018	2014

Box 1.1 SGCN Criteria for Delaware Wildlife Action Plan 2015

Species were considered a *candidate* for GCN status if they **occur in Delaware** AND they met any one of the following criteria:

1. Federally Endangered, Threatened, or Candidate status

2. State Legal Status of Endangered

3. Global Rank of G3 or higher, or any combination rank that includes G3

4. S-Rank of S2 or higher, SH, or SX for Breeding, Nonbreeding or Both

5. Regional Species of Greatest Conservation Need (RSGCN) for the Northeast

6. IUCN Red List Status of Near Threatened or higher

7. Taxon-specific Conservation Concern. Included at the following levels on the following taxon-specific plans:

Birds: Mid-Atlantic Bird Conservation Initiative BCR 29 or BCR 30 "Highest Priority" and "High Priority" Species

Fishes and Marine Invertebrates: National Oceanic and Atmospheric Administration (NOAA) NMFS Species of Concern (NOAA 2010), American Fisheries Society (2001) Marine, Estuarine, and Diadromous Fish Stocks at Risk of Extinction in North America (Exclusive of Pacific Salmonids), American Fisheries Society (2008) List of imperiled North American freshwater and diadromous fishes, Atlantic States Marine Fisheries Commission (ASMFC) Managed Species

Reptiles & Amphibians: NEPARC (2010) Northeast Amphibian and Reptile Species of Regional Responsibility and Conservation Concern

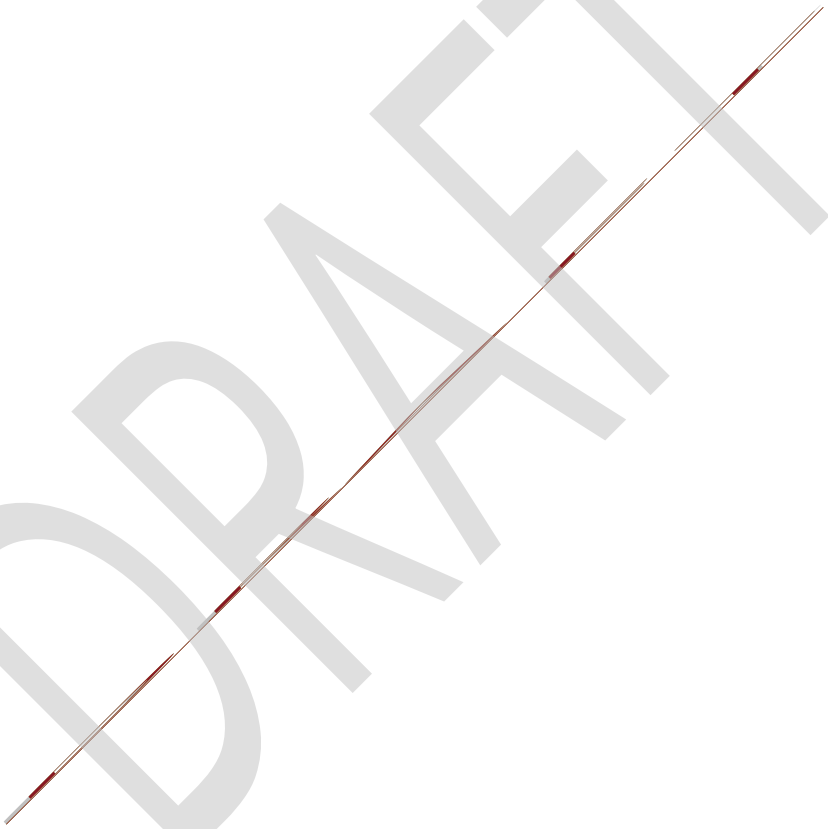
Odonates: White, et al. (2014) A conservation status assessment of Odonata for the northeastern United States. New York Natural Heritage Program, Albany, NY.

8. Endemic, Near-Endemic, or Disjunct. (Species which, according to the best available data are endemic or near-endemic to the Delmarva Peninsula, or whose Delaware populations are widely disjunct: 200+ miles from the species main range of distribution)

9. Scientific Data and Expert Consensus

Taxa that do not meet other SGCN criteria that can be demonstrated by scientific evidence or expert consensus to have at least a moderate risk of extinction in the future, or that have especially significant Delaware populations. This may include taxa that are data deficient, have demonstrated population declines, rarity or limited habitat requirements, need direct species management in order to persist, have at-risk populations, or are likely to be significantly negatively impacted by climate change or other specific and imminent threats.

Figure 1. 8 SGCN Criteria for Delaware Wildlife Action Plan 2015



Box 1.2 Decision Tree for Screening SGCN from SGCN Candidate List

1. Is the species native or thought to be native to Delaware or adjacent waters (including North American native species whose range has expanded naturally into the region)?

YES: continue NO: not SGCN

2. Is Delaware within, or presumed to be within, the species' regularly occurring range, now or at some time in the past? Accidental and vagrant species should not be included, even if there are multiple records. Disjunct populations should be considered part of the regularly occurring range.

YES: continue NO: not SGCN

3. If the species is included solely on the basis of a breeding season S-rank, does that rank reflect only sporadic, accidental breeding attempts well outside the usual breeding range of the species? (Any evidence of continued breeding or establishment of a breeding population should be considered.)

YES: not SGCN NO: continue

4. If the species is considered extirpated from Delaware (SX), is there some possibility that the species could either recolonize naturally or be intentionally reintroduced in the foreseeable future?

Yes: SGCN NO: Not SGCN

5. Is the species a rare or casual migrant or rare seasonal visitor in Delaware such that threats and conservation actions present /conducted over the next 10 years in Delaware are unlikely to have a measurable impact on the species' population?

YES: not SGCN NO: continue

6. Are there potential, feasible conservation actions that could be implemented within Delaware that may result in a measurable impact on the species' population? (Including reintroduction)

YES: SGCN NO: not SGCN

Figure 1. 9 Decision Tree for Screening SGCN from SGCN Candidate List

The database query process using Criteria 1-7 from **Box 1.1** generated an initial list of taxa for consideration. Additional taxa that were not picked up by the initial database query were added to the draft list based on Criteria 8 or 9. Some of these taxa, such as the firefly *Photuris mysticalampas* and the frog *Rana kauffeldi* are newly recognized species that will likely meet both State and Global Rank Criteria once they are officially ranked. Several native bee species are not yet S-ranked, but are globally or regionally rare and were added on the basis of rangewide declines and historical occurrence in Delaware. It is likely that more species of native bees will be added during further

review of that group. One species of butterfly, the Monarch (*Danaus plexippus*) was added on the basis of current critical rangewide declines that are not yet reflected in state or global ranks. A few species, including two species of spider wasps (*Psorthaspis* sp.) were added based on disjunct distribution as described in Criterion 8. Two species, the blue crab (*Callinectes sapidus*) and the American oyster (*Crassostrea virginica*) were added based on criteria 9 due to their dependence on management activities to build and maintain populations. A handful of other species were added based on anticipated S rank changes to be updated during the course of the WAP process (some fireflies, bats, etc.) A complete list of species added since 2007, along with their corresponding criteria met, is included as **Appendix 1.C**.

After screening using the decision framework shown in the green box above to remove several accidental and extralimital taxa, the final SGCN list contains 671 taxa.

SGCN Prioritization

The Association of Fish and Wildlife Agencies (AFWA) identified the need for greater prioritization of SGCN in the Best Practices for State Wildlife Action Plans (AFWA 2012).

Once the SGCN list was updated using the selection criteria described above, taxonomic experts for each group were again asked to review the SGCN list for their taxa and provide data on regional and state level responsibility and concern for each species. The answers to these evaluations were used, along with S-ranks, G-ranks, and other available information, to create an overall SGCN Prioritization Index. The Prioritization Index was then used to group GCN species into a series of tiers based on natural breaks in the score distribution.

The general approach of prioritizing species for conservation using a scoring system based on ordinal transformations from variables assessed by expert opinion and available data was pioneered in state wildlife planning by Millsap (1990) for the state of Florida, and modified versions of similar systems are currently in use in Florida (Florida Fish and Wildlife Conservation Commission Species Ranking System) and Alaska (Alaska Species Ranking System). While the Millsap (1990) system was based on determining extinction risk (similar to the well-known IUCN Red List), similar methods using various criteria have been applied to set conservation priorities for individual taxonomic groups of interest, including plants (Jiménez-Alfaro et al. 2010, Safont et al. 2012), beetles (Abellán et al. 2005) and butterflies (Zeydanli et al. 2012).

The general formula for the Prioritization Index (PI) is $PI = \Sigma(\lambda_i \cdot C_i)$, where C_i corresponds to the assessment criteria and λ_i is the weight factor of each criterion. λ_i adds up a value of 100 and this is distributed among C_i, such that higher weights indicate a greater relative importance of the criterion.

The criteria and proposed relative weights used in the PI calculation were reviewed by taxa experts prior to finalizing. The criteria to be used in the Prioritization Index are as follows:

1. Federal Legal Status
2. State Legal Status
3. Global Rank (G-Rank)
4. State Rank (S-Rank)
5. State Responsibility
6. Regional (Northeast) Responsibility Level
7. Regional (Northeast) Concern Level
8. Climate Change Vulnerability
9. Sea Level Rise Vulnerability

The Prioritization Index provides an estimate of the relative conservation priority of a taxon. These scores should be viewed as grouping species into broad categories of priority, rather than as exact scores. Because of the differences in type and quality of data sources, care should be exercised when comparing taxa across broad taxonomic groups.

Data Gaps and Uncertainty

For many species, reliable data may not be available. In some cases, particularly with invertebrates, some or all aspects of basic life history may be unknown. In dealing with data deficiencies, gaps, and complete unknowns, the DEWAP process endeavors to:

a. Use expert opinion based on the current scientific literature and your understanding of the taxon;

b. Use information and data from related taxa;

c. Document level of certainty and what information decisions were based on.

Species Conservation Approaches

This revision of the Delaware Wildlife Action Plan presents a practical approach to the conservation of species and habitats. Species prioritization, as discussed above, is based on rarity, threats, and regional and state responsibility.

Surrogate Species

In 2012, the U.S. Fish & Wildlife Service committed to using a Strategic Habitat Conservation (SHC) approach that emphasizes the use of surrogate species in biological and conservation planning. In 2014, a draft Technical Guidance on Selecting Species for Design of Landscape Scale Conservation was circulated (USFWS 2014). Peer review indicated significant concern about the scientific support for the use of surrogate species approaches (USFWS Region 6 Office 2014). The North Atlantic Landscape Conservation Cooperative (NALCC) and US Fish and Wildlife Service Region 5, along with partners at University of Massachusetts Amherst and the US Forest Service had already (in 2011) initiated the process of identifying "representative species" for clusters of ecological system-level habitats in the Northeast based on an analysis of expert-assigned species-habitat matrices for SGCN in the region. This process resulted in the identification of a total of 87 "representative species", 66 of them birds, for 30 different habitat clusters in the region (USFWS 2012), plus 13 aquatic "representative species", one for each habitat type included (USFWS n.d.). These species are included for each habitat in Chapter 2. These regional "representative species" adequately reflect species that are closely associated with particular broad suites of habitats. However, most of the selected species will require more detailed validation in order to be used confidently as indicator or umbrella species.

The use of surrogate species to achieve the goals of particular projects within Delaware should be encouraged as a matter of practicality, but the challenges of such an approach should be clearly understood and surrogate species should be validated for their correlation with responses of target species and taxonomic groups. The suitability of any particular surrogate species approach (e.g., umbrella, indicator, flagship) depends on the specific conservation goals and objectives of the application. For this reason, these concepts are not directly addressed in SGCN selection or ranking for the DEWAP.

Umbrella Species

Sattler et al (2014) found that although most umbrella species do well in predicting high taxonomical diversity within their respective taxa, they are not necessarily good predictors of diversity within other taxa (supported by Fattorini et al 2011). Two exceptions to these findings in the urban habitats in this study were bees and spiders, both of which performed much better as indicators of high diversity in other groups, dramatically outperforming birds in this respect.

Functional diversity and taxonomical diversity are often not well-represented by a single umbrella species, so the approach of selecting multiple, complementary umbrella species is necessary. Due to the complexity of applying the umbrella species concept across numerous taxa, habitats, and functional groups, the DEWAP does not include a species' status as an umbrella species as an inclusion criterion for GCN listing.

Indicator Species

The status of a species as an indicator of environmental condition or habitat quality is likewise not explicitly included in the selection or prioritization criteria of SGCN in the DEWAP. While many species may serve as indicators depending on the goal of the assessment, indicator species should be validated empirically relative to the variable of interest, and a broad screening of all taxa for their relative suitability as indicators of various environmental conditions is beyond the scope of the DEWAP.

Literature Cited

Abell, R., D. M. Olson, E. Dinerstein, P. Hurley, J. T. Diggs, W. Eichbaum, S. Walters, W. Wettengel, T. Allnutt, C. J. Loucks, P. Hedao, and C. Taylor. 2000. *Freshwater Ecoregions of North America: A Conservation Assessment*. Washington, D.C. Island Press.

Able, K. W. and M. P. Fahay. 2010. *Ecology of estuarine fishes: temperate waters of the Western North Atlantic*. The Johns Hopkins University Press, Baltimore, MD.

Adams, M.J., Miller, D.A.W., Muths, E., Corn, P.S., Grant, E.H.C., et al. (2013) Trends in Amphibian Occupancy in the United States. *PLoS ONE* 8(5): e64347.doi:10.1371/journal.pone.0064347

Anderson, M.G., M. Clark, C.E. Ferree, A. Jospe, A. Olivero Sheldon, and K.J. Weaver. 2013a. *Northeast Habitat Guides: A companion to the terrestrial and aquatic habitat maps*. Submitted to the Regional Conservation Needs Grants Program of the Northeast Association of Fish and Wildlife Agencies. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA. 394 pp. (http://static.rcngrants.org/sites/default/files/news_files/Northeast%20Aquatic%20and%20Terrestrial%20Habitat%20Guide.pdf)

Anderson, M.G., M. Clark, C.E. Ferree, A. Jospe, and A. Olivero Sheldon. 2013b. *Condition of the Northeast Terrestrial and Aquatic Habitats: a geospatial analysis and tool set*. Submitted to the Regional Conservation Needs Grants Program of the Northeast Association of Fish and Wildlife Agencies. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA. 179 pp. http://easterndivision.s3.amazonaws.com/Geospatial/ConditionoftheNortheastTerrestrialandAquaticHabitats.pdf

Atlantic Coast Joint Venture (ACJV). 2005. Atlantic Coast Joint Venture Waterfowl Implementation Plan. Focus Areas

Atlantic Coastal Fish Habitat Partnership. 2009. *Species-Habitat Matrix Project Summary Report*. 28 pp.

Atlantic Coastal Fish Habitat Partnership. 2012. *Atlantic Coastal Fish Habitat Partnership Conservation Strategic Plan 2012-2016*.

AFWA. 2012. Best Practices for State Wildlife Action Plans: Voluntary Guidance to States for Revision and Implementation. Teaming With WildlifeCommittee's State Wildlife Action Plan

(SWAP) Best Practices Working Group. November 2012. 68 pp. Available online at: http://www.fishwildlife.org/files/SWAPBestPractices.pdf

Anderson, M.G. and A. Olivero Sheldon. 2011. Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework. The Nature Conservancy, Eastern Conservation Science. 289 pp.

Anderson, M.G., M. Clark, C.E. Ferree, A. Jospe, A. Olivero Sheldon, and K.J. Weaver. 2013. Northeast Habitat Guides: A companion to the terrestrial and aquatic habitat maps. Submitted to the Regional Conservation Needs Grants Program of the Northeast Association of Fish and Wildlife Agencies. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA. 394 pp. http://static.rcngrants.org/sites/default/files/news_files/Northeast%20Aquatic%20and%20Terrestrial%20Habitat%20Guide.pdf

Andres et al. (2012). *Population estimates of North American shorebirds*.

Askins, R. A. 1997. History of grasslands in the northeastern United States: Implications for bird conservation. Pages 119-136 *In* Vickery, P. D. and P. W. Dunwiddie. Grasslands of Northeastern North America: ecology and conservation of native and agricultural landscapes. Massachusetts Audubon Society, Lincoln, MA.

Askins, R.A. 2000. Restoring North America's birds. Yale University Press, New Haven

Atlantic States Fishery Management Council (ASFMC). Fishery Management Plans. 2014. Available online at: http://www.asmfc.org/ Accessed April 8, 2014.

Barbour, M., J. Gerritsen, B. Snyder, & J. Stribling. 1999. *Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates, and fish*. 2nd edition. Washington, DC, US EPA 841-B-99-002.

Bart, J., Andres, B., Brown, S., Donaldson, G., Harrington, B., Johnson, H., ... & Warnock, N. (2002). *Program for Regional and International Shorebird Monitoring (PRISM)*, version 0.7. http://www.shorebirdplan.org/wp-content/uploads/2013/01/PRISMOverview1_02.pdf

Bland, L.M., Collen, B., Orme, C. D. L. and Bielby, J. (2014). Predicting the Conservation Status of Data-Deficient Species. *Conservation Biology*. doi: 10.1111/cobi.12372

Boakes EH, McGowan PJK, Fuller RA, Chang-qing D, Clark NE, et al. (2010) Distorted Views of Biodiversity: Spatial and Temporal Bias in Species Occurrence Data. *PLoS Biology* 8(6): e1000385. doi:10.1371/journal.pbio.1000385

Breeding Bird Atlas (BBA) Explorer (online resource). 2015. U.S. Geological Survey Patuxent Wildlife Research Center. http://www.pwrc.usgs.gov/bba. Data compiled from: Delaware Breeding Bird Atlas 2008-2012. Delmarva Ornithological Society. Interim results used with permission

Brown, S., C. Hickey, B. Harrington, and R. Gill, eds. 2001. The United States Shorebird Conservation Plan. Manomet Center for Conservation Sciences. May 2001 2nd Edition. 64 pp.

Bushman, E. S. and G. D. Therres. 1988. Habitat management guidelines for forest interior breeding birds of coastal Maryland. Maryland Department of Natural Resources, Forest, Park and Wildlife Service, Wildlife Technical Publication 8-1. 50 pp.

Cadotte, M. W., Carscadden, K., & Mirotchnick, N. (2011). Beyond species: functional diversity and the maintenance of ecological processes and services.*Journal of applied ecology*, *48*(5), 1079-1087.

Calhoun, A.J.K. and M.W. Klemens. 2002. *Best development practices: Conserving post-breeding amphibians in residential and commercial developments in the northeastern United States.* Metropolitan Alliance. Wildlife Conservation Society, New York.

Camhi, M.D., Valenti, S.V., Fordham, S.V., Fowler, S.L. and Gibson, C. 2009. *The Conservation Status of Pelagic Sharks and Rays: Report of the IUCN Shark Specialist Group Pelagic Shark Red List Workshop.* IUCN Species Survival Commission Shark Specialist Group. Newbury, UK. x + 78p. http://sharkadvocates.org/ssg_pelagic_report_final.pdf

The Center for Conservation Biology. 2014. "Black rail population status". http://www.ccbbirds.org/what-we-do/research/species-of-concern/blackrail/population/

Clark, K.E. and Niles L.J. 2001. *Northern Atlantic Regional Shorebird Plan*. Version 1.0. New Jersery Division of Fish and Wildlife. Woodbine, NJ.. http://www.fws.gov/shorebirdplan/regionalshorebird/downloads/NATLAN4.pdf

Clark, K E., L.J. Niles and J Burger. 1993. Abundance and distribution of migrant shorebirds in Delaware Bay. *Condor* 95: 694-705.

Cole, J. C., P. A. Townsend, and K. N. Eshleman. 2008. *Predicting flow and temperature regimes at three Alasmidona heterodon locations in the Delaware River*. Technical Report NPS/NER/NRTR-2008/109. National Park Service. Philadelphia, PA.

Connecticut Department of Environmental Protection (CTDEP). 2003. *A Field Guide to the Freshwater Mussels of Connecticut*. CTDEP, Bureau of Natural Resources, Wildlife Division. Hartford, CT.

Conway, C. J. 2009. *Standardized North American Marsh Bird Monitoring Protocols, version 2009-2*. Wildlife Research Report #2009-02. U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, Tucson, AZ.

Cornelisse, T. M., & Hafernik, J. E. (2009). Effects of soil characteristics and human disturbance on tiger beetle oviposition. *Ecological Entomology*, *34*(4), 495-503.

Coxe, R. 2014. *Guide to Delaware Vegetation Communities and Land Covers, Fall 2014*. 518 pp.

Craig, L. J., and D. S. Dobkin. 1993. Community dynamics of small mammals in mature and logged Atlantic white cedar swamps of the New Jersey Pine Barrens. New York State Museum Bulletin No. 487. The University of the State of New York, the State Education Department.

Crosby, A. D., Elmore, R. D., Leslie, D. M., & Will, R. E. (2015). Looking beyond rare species as umbrella species: Northern Bobwhites (Colinus virginianus) and conservation of grassland and shrubland birds. *Biological Conservation*, *186*, 233-240.

Dalerum, F., Cameron, E. Z., Kunkel, K., & Somers, M. J. (2009). Diversity and depletions in continental carnivore guilds: implications for prioritizing global carnivore conservation. *Biology Letters*, *5*(1), 35–38.

Delaware Board Game and Fish Comm. 1942. *Status of Delaware wildlife – conservation: in relation to the seed stock refuge program, three-year summary under Pittman-Robertson Federal Aid in Wildlife Restoration Act.* Bulletin No. 4. Dover, DE, Aug 1942.

Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife (DNREC DFW). 2014. *Draft Delaware Delmarva Fox Squirrel Conservation Plan*. 64 pp. plus Appendices. http://www.dnrec.delaware.gov/fw/NHESP/Documents/DFS_Draft Conservation Plan March 2014.pdf

Delaware Department of Natural Resources and Environmental Control (DNREC). 2005. Delaware Bay and Estuary assessment report: whole basin. 156 pp. http://www.dnrec.delaware.gov/WholeBasin/Documents/DelawareBayAssessmentPages.pdf

Delaware Forest Service. 2010. *Delaware Forest Resource Assessment*. 79 pp. http://dda.delaware.gov/forestry/061810_DFS_ResourceAssessment.pdf

Devictor, V., Mouillot, D., Meynard, C., Jiguet, F., Thuiller, W., & Mouquet, N. (2010). Spatial mismatch and congruence between taxonomic, phylogenetic and functional diversity: the need for integrative conservation strategies in a changing world. *Ecology letters*, *13*(8), 1030-1040.

Dunn, R.R.. 2005. Modern insect extinctions, the neglected majority. *Conservation Biology* 19(4): 1030-1036.

Ellis, J. C., & Good, T. P. (2006). Nest attributes, aggression, and breeding success of gulls in single and mixed species subcolonies. *The Condor, 108*(1), 211-219.

Fairchild, G. W., Faulds, A. M., & Matta, J. F. (2000). Beetle assemblages in ponds: effects of habitat and site age. *Freshwater Biology*, *44*(3), 523-534.

FGDC (Federal Geographic Data Committee). 2012. FGDC-STD-018-2012 *Coastal and Marine Ecological Classification Standard*. Reston, VA. Federal Geographic Data Committee. 343 pp.

Fox, D.A., Wetherbee, B.M., Brown, L., Shivji, M.S., Sulak, K., and Moore, J. 2009. "Coastal Movements of Sand Tiger Sharks (*Carcharias taurus*) in the Northwest Atlantic as Determined by Acoustic and Satellite Telemetry". *Oceanography Faculty Proceedings, Presentations, Speeches, Lectures.* Paper 124. http://nsuworks.nova.edu/occ_facpresentations/124

Gawler, S. C. 2008. *Northeastern Terrestrial Wildlife Habitat Classification*. Report to the Virginia Department of Game and Inland Fisheries on behalf of the Northeast Association of Fish and Wildlife Agencies and the National Fish and Wildlife Foundation. NatureServe, Boston, Massachusetts. 102 pp.

Gibbons, J.W.; Scott, D.E.; Ryan, T.J.; Buhlmann, K.A.; Tuberville, T.D.; Metts, B.S.; Greene, J.L.; Mills, T.; Leiden, Y.; Poppy, S.; and Winne, C.T. 2000. The global decline of reptiles, déjà vu amphibians. *BioScience* 50: 653-666.

Green, J. W. 1957. A revision of the Nearctic Species of *Pyractomena* (Coleoptera: Lampyridae). *The Wasman Journal of Biology* 15:237-284.

Greene, K. E., J. L. Zimmerman, R. W. Laney, and J. C. Thomas-Blate. 2009. *Atlantic Coast diadromous fish habitat: a review of utilization, threats, recommendations for conservation and research needs*. Atlantic States Marine Fisheries Commission Habitat Management Series #9, Washington, D.C.

Haag, W. R. (2012). *North American freshwater mussels: natural history, ecology, and conservation*. Cambridge University Press.

Hawkins, C. P., Mykrä, H., Oksanen, J., & Vander Laan, J. J. (2015). Environmental disturbance can increase beta diversity of stream macroinvertebrate assemblages. *Global Ecology and Biogeography*,*24*(4), 483-494.

Heckscher, C. M. 1995. Distribution and habitat associations of the Eastern Mud Salamander, *Pseudotriton montanus montanus*, on the Delmarva Peninsula. *The Maryland Naturalist* 39(1-2):11-14.

Heckscher, C. M. 2000. Forest-dependent birds of the Great Cypress (North Pocomoke) Swamp: Species composition and implications for conservation. *Northeastern Naturalist*, *7*(2), 113-130.

Heckscher, C. M. 2010. Delaware *Photuris* fireflies (Coleoptera: Lampyridae): New state records, conservation status, and habitat associations. Entomological News 121:498-505.

Heckscher, C. M. 2013. *Photuris mysticalampas* (Coleoptera: Lampyridae): A new firefly from peatland floodplain forests of the Delmarva Peninsula. Entomological News 123:93-99.

Heckscher, C. M. 2014. Northern range extension of *Psorthaspis sanguinea* (Smith) (Hymenoptera: Pompilidae) and a record of *Psorthaspis mariae* (Cresson) from the Delmarva Peninsula. Northeastern Naturalist 21:N53 – N55.

Heckscher, C. M. and C. R. Bartlett. 2004. Rediscovery and habitat associations of *Photuris bethaniensis* McDermott (Coleoptera: Lampyridae). The Coleopterists Bulletin 58:349-353.

Heckscher, C.M. and K.A. Bennett. 1999. *Delaware's freshwater mussel surveys 1997-1999: results and implications for conservation.* Final report submitted to U.S. Fish & Wildlife Service, Dec. 1999. 18 pp.

Heckscher, C. M. and J. E. Lloyd. In press. An isolated occurrence of *Pyractomena ecostata* (LeConte) (Coleoptera: Lampyridae) in the Mid-Atlantic with records from New Jersey and Delaware. *Northeastern Naturalist*.

Hess, G. K., R. L. West, M. V. Barnhill and L. M. Fleming. 2000. *Birds of Delaware*. University of Pittsburgh Press, Pittsburgh.

Hoback, W. W., Golick, D. A., Svatos, T. M., Spomer, S. M., & Higley, L. G. (2000). Salinity and shade preferences result in ovipositional differences between sympatric tiger beetle species. *Ecological Entomology*, *25*(2), 180-187.

Hooper, D. U., Chapin III, F. S., Ewel, J. J., Hector, A., Inchausti, P., Lavorel, S., ... & Wardle, D. A. 2005. Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. *Ecological monographs*, *75*(1), 3-35.

Horwitz, R., P. Overbeck, D. Keller, and S. Moser. 2008. Fish inventories of Delaware Water Gap National Recreation Area and Upper Delaware Scenic and Recreational River. Academy of Natural Sciences Report No. 08-06. Prepared for U.S. Department of the Interior, National Park Service, Northeast Region. Philadelphia, PA.

Johnson, D. H., J. P. Gibbs, M. Herzog, S. Lor, N. D. Niemuth, C. A. Ribic, M. Seamans, T. L. Shaffer, W. G. Shriver, S. Stehman, and W. L. Thompson. 2009. A sampling design framework for monitoring secretive marshbirds. *Waterbirds* 32:203–215.

Jones, C., J. McCann, and S. McConville. 2000. *A guide to the conservation of forest interior dwelling birds in the Chesapeake Bay Critical Area*. Critical Area Commission for the Chesapeake and Atlantic Coastal Bays. Annapolis, MD. 58 pp.

Jones, M.T., L.L. Willey, T.S.B. Akre, and P.R. Sievert. 2014. *Status and Conservation of the Wood Turtle in the Northeastern United States*. Draft reported submitted to the Northeast Association of Fish and Wildlife Agencies for Regional Conservation Needs Grant 2011-02.

Knisley, C. B. and T. D. Schultz. 1997. *The Biology of Tiger Beetles and a Guide to the Species of the South Atlantic States*. Virginia Museum of Natural History, Martinsville, Virginia, viii + 210 pp.

Knisley, C. B., Kippenhan, M., and Brzoska, D. 2014. Conservation status of United States tiger beetles. *Terrestrial Arthropod Reviews*, 7(2-4): 93-145.

Koch, S.L. and P.W.C. Paton. 2009. *Shorebird migration chronology at a stopover site in Massachusetts*. Wader Study Group Bulletin 116: 167-174.

Kreeger, D., A.T. Padeletti, and D.C. Miller. September 2010. *Delaware Estuary Benthic Inventory (DEBI): an exploration of what lies beneath the Delaware Bay and River*. Partnership for the Delaware Estuary, PDE Report No. 11-06. 71 pp.

Kushlan, J. A., M. J. Steinkamp, K. C. Parsons, J. Capp, M. A. Cruz, M. Coulter, I. Davidson, L. Dickson, N. Edelson, R. Elliot, R. M. Erwin, S. Hatch, S. Kress, R. Milko, S. Miller, K. Mills, R. Paul, R. Phillips, J. E. Saliva, B. Sydeman, J. Trapp, J. Wheeler, and K. Wohl. 2002. *Waterbird Conservation for the Americas: The North American Waterbird Conservation Plan, Version 1*. Waterbird Conservation for the Americas, Washington, DC, U.S.A., 78pp. http://www.pwrc.usgs.gov/nacwcp/nawcp.html

Lake, R.W. 1980. Distribution of the stoneflies (Plecoptera) of Delaware. *Entomological News* 91(2): 43-48.

Lake, R.w. 1984. Distribution of the caddisflies (Trichoptera) of Delaware. *Entomological News* 95: 215-224.

LaRoe, E.T., G.S. Farris, C.E. Puckett, P.D. Doran and M.J. Mac. eds. 1995. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. Washington, DC :U.S. Dept. of the Interior, National Biological Service 530 pp.

MANEM Waterbird Working Group. 2006. *Waterbird Conservation Plan for the Mid-Atlantic/New England/Maritimes Region: 2006-2010*. Waterbird Conservation for the Americas. http://www.waterbirdconservation.org

Martin, C. 2010. Turtles in Trouble, pages 3-9 *in* Outdoor Delaware, summer issue. Department of Natural Resources and Environmental Control. Dover, DE.

Mid-Atlantic Regional Council on the Ocean (MARCO). Data Portal. http://midatlanticocean.org/data-portal/

McCandless, C.T., H.L. Pratt, Jr., and N.E. Kohler. 2007. Distribution, localized abundance, movements, and migrations of juvenile Sandbar Sharks tagged in Delaware Bay. Pp. 45–62, In C.T. McCandless, N.E. Kohler, and H.L. Pratt, Jr. (Eds.). Shark Nursery Grounds of the Gulf of Mexico and the East Coast Waters of the United States. American Fisheries Society Symposium 50. American Fisheries Society, Bethesda, MD.

McCann, J. M., Mabey, S. E., Niles, L. J., Bartlett, C., & Kerlinger, P. (1993). A regional study of coastal migratory stopover habitat for Neotropical migrant songbirds: land management implications. In *Transactions of the North American Wildlife and Natural Resources Conference* 58: 398-407.

McDermott, F. A. 1953. *Photuris bethaniensis*, a new Lampyrid firefly. Proceedings of the U. S. National Museum 103:35-37.

McDermott, F. A. 1967. The North American fireflies of the genus *Photuris* DeJean a modification of Barber's key (Coleoptera: Lampyridae). The Coleopterists Bulletin 21:106-116.

McIntosh IV, C. E., & Short, A. E. Z. (2012). New Delaware, USA Records and Notes About the Endangered Seth Forest Water Scavenger Beetle (Coleoptera: Hydrochidae). *The Coleopterists Bulletin*, *66*(3), 294-296.

Merritt, R. W., & Cummins, K. W. (1996). *An introduction to the aquatic insects of North America*. Kendall Hunt.

Merson, R. R., & Pratt Jr, H. L. (2001). Distribution, movements and growth of young sandbar sharks, Carcharhinus plumbeus, in the nursery grounds of Delaware Bay. *Environmental Biology of Fishes*, *61*(1), 13-24.

Mid-Atlantic Fishery Management Council (MAFMC). Fishery Management Plans. Available online at: http://www.mafmc.org/mid-atlantic/fmp/fmp.htm Accessed April 8, 2014.

Miller, H.E. and M.J. Jordan. 2011. Relationship between exotic invasive shrubs and America woodcock (*Scolopax minor*) nest success and habitat selection. *Journal of the Pennsylvania Academy of Science* 85(4): 132-139.

The National Bobwhite Technical Committee. 2011. Palmer, W.E., T.M. Terhune, and D.F. McKenzie (eds). *The National Bobwhite Conservation Initiative: A range-wide plan for recovering bobwhites.* National Bobwhite Technical Committee Technical Publication, ver. 2.0 , Knoxville, TN.

NOAA National Marine Fisheries Service (NMFS). n.d. *Atlantic Sturgeon New York Bight Distinc t Population Segment: Endangered.* http://www.nmfs.noaa.gov/pr/pdfs/species/atlanticsturgeon_nybright_dps.pdf

Narvaez, M.C., G.J. Kauffman, R. Lonsdorf, and M.H.S. Nelson. 2010. Restoration of shad and anadromous fish to the White Clay Creek National Wild and Scenic River: a feasibility report. June 2010. 101 pp. https://whiteclay.org/wp-content/uploads/2013/02/ShadRestoration.pdf

Natural Resources Conservation Service (NRCS). 2007. *Pollinators*. Fish and Wildlife Habitat Management Leaflet. No. 34. 1-10.

Nazdrowicz, N. H. (2003). *Population ecology of the eastern box turtle (Terrapene carolina carolina) in a fragmented landscape* (Doctoral dissertation, University of Delaware).

Nebel, S., A. Mills, J. D. McCracken, and P. D. Taylor. 2010. Declines of aerial insectivores in North America follow a geographic gradient. *Avian Conservation and Ecology - Écologie et conservation des oiseaux* **5**(2): 1. [http://www.ace-eco.org/vol5/iss2/art1/

Nedeau, E. J., M. A. McCollough, and B. I. Swarts. 2000. *The Freshwater Mussels of Maine*. Maine Department of Inland Fisheries and Wildlife. Augusta, ME.

Nekola, J. C. (2003). Large-scale terrestrial gastropod community composition patterns in the Great Lakes region of North America. *Diversity and Distributions*, *9*(1), 55-71.

Nekola, J. C. (2005). Geographic variation in richness and shell size of eastern North American land snail communities. *Records of the Western Australian Museum Supplement*, *68*, 39-51.

New T. R. 2010. Beetles in conservation. Wiley-Blackwell, Oxford.

New T. R. (ed.) 2012a. Insect conservation: past, present and prospects. Springer, Dordrecht.

New T. R. 2012b. Hymenoptera and conservation. Wiley-Blackwell, Oxford.

Niederriter, H.S. and R. R. Roth. 2003. Ecology of eastern box turtles (*Terrapine carolinacarolina*) in an isolated forest fragment in Northern Delaware. Conservation and Ecology of Turtles of the Mid-Atlantic Region, a Symposium 63-71.

North American Bird Conservation Initiative, U.S. Committee, 2009. The State of the Birds, United States of America, 2009. U.S. Department of Interior: Washington, DC. 36 pages.

NEFWDTC. 2013. Taking Action Together: Northeast Regional Conservation Synthesis for State Wildlife Action Plan Revisions. Prepared by Terwilliger Consulting Inc. December 2013 Revised April 2014. http://rcngrants.org/project-final-reports

Northeast Partners for Amphibian and Reptile Conservation (NEPARC). 2004. Model state herpetofauna regulatory guidelines. 6pp. Available online at: http://www.northeastparc.org/products/pdfs/HERPETOFAUNARegulatoryGuidelines.pdf

Northeast Partners for Amphibian and Reptile Conservation (NEPARC). 2009. Northeast habitat management guidelines. Available online at: http://www.northeastparc.org/products/hmg.htm

Olivero, A.P. and M.G. Anderson. 2008. *Northeast Aquatic Habitat Classification System*. The Nature Conservancy, in collaboration with the Northeast Association of Fish and Wildlife Agencies. 88 pp.

Osowski, S. L., Brewer, L. W., Baker, O. E., & Cobb, G. P. (1995). The decline of mink in Georgia, North Carolina, and South Carolina: the role of contaminants. *Archives of environmental contamination and toxicology*, *29*(3), 418-423.

Parsons, K. C. 1995. Heron nesting at Pea Patch Island, upper Delaware Bay, USA: Abundance and reproductive success. *Colonial Waterbirds* 18: 69-78.

Parsons, K. C. and A. C. McColpin. 1995. Great Blue Heron reproductive success in upper Delaware Bay. *Journal of Field Ornithology* 66: 184-191.

Parsons, K. C., S. R. Schmidt and A. C. Matz. 2001. Regional patterns of wading bird productivity in northeastern U.S. estuaries. *Waterbirds* 24: 323-330.

Partners in Flight Science Committee 2013. Population Estimates Database, version 2013. Available at http://rmbo.org/pifpopestimates. Accessed on <date>.

Pavlikova, A., & Konvicka, M. (2012). An ecological classification of Central European macromoths: habitat associations and conservation status returned from life history attributes. *Journal of Insect Conservation*, *16*(2), 187-206.

Pleasants, J. M., & Oberhauser, K. S. (2013). Milkweed loss in agricultural fields because of herbicide use: effect on the monarch butterfly population. *Insect Conservation and Diversity*, *6*(2), 135-144.

Raasch, M. S. 1997. Delaware's freshwater and brackish-water fishes, a popular account, 3rd edition. Delaware Nature Society, Hockessin, DE. 174 p.

Rawlins, J. and C. Bier. n.d. Invertebrates: review of status in Pennsylvania. Pennsylvania Biological Survey. http://www.altoona.psu.edu/pabs/invertebrates.htm

Rechisky, E. L., & Wetherbee, B. M. (2003). Short-term movements of juvenile and neonate sandbar sharks, Carcharhinus plumbeus, on their nursery grounds in Delaware Bay. *Environmental Biology of Fishes*, *68*(2), 113-128.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, T. C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY. Partners in Flight website. *http://www.partnersinflight.org/cont_plan/* (VERSION: March 2005).

Robbins, Chandler S., Deanna K. Dawson, and Barbara A. Dowell. 1989. Habitat Area Requirements of Breeding Forest Birds of the Middle Atlantic States. Wildlife Monograph no. 103. Wildlife Society. Blacksburg, VA.

Rosenberg, K. V. 2004. Association of Fish and Wildlife Agencies Partners in Flight Landbird Reports. *http://fishwildlife.org/allbird_landbird.html*

Rosenberg, K.W. and J. V. Wells. 2005. Conservation priorities for terrestrial birds in the Northeastern United States. USDA Forest Service Gen. Tech. Rep. PSW-GTR-191.

Sattler, T., Pezzatti, G. B., Nobis, M. P., Obrist, M. K., Roth, T. and Moretti, M. (2014), Selection of Multiple Umbrella Species for Functional and Taxonomic Diversity to Represent Urban Biodiversity. Conservation Biology, 28: 414–426. doi: 10.1111/cobi.12213

Schulte, S., S. Brown, D. Reynolds, and the American Oystercatcher Working Group. 2007. Version 2.0. A Conservation Action Plan for the American Oystercatcher (*Haematopus palliates*) for the Atlantic and Gulf Coasts of the United States. 41 pp. *http://www.fws.gov/migratorybirds/CurrentBirdIssues/Management/FocalSpecies/Plans/AMOY.pdf*

Schultz, T. D. (1989). Habitat Preferences and Seasonal Abundances of Eight Sympatric Species of Tiger Beetle, Genus Cicindela (Coleoptera: Cicindelidae), in Bastrop State Park, Texas. *The Southwestern Naturalist*, 468-477.

Schultz, T. (1998). The utilization of patchy thermal microhabitats by the ectothermic insect predator, Cicindela sexguttata. *Ecological Entomology*,*23*(4), 444-450.

Schweitzer, D. F., M. C. Minno, and D. L. Wagner. 2011. Rare, Declining, and Poorly Known Butterflies and Moths (Lepidoptera) of Forests and Woodlands in the Eastern United States. U.S. Forest Service, Forest Health Technology Enterprise Team, FHTET-2011-01.

SHARP, 2012. Compiled overview for the 2012 field season. The Conservation of Tidal Marsh Birds: guiding action at the intersection of our changing land and seascapes. http://www.tidalmarshbirds.net

Short, A. E. Z. (2004). SCIENTIFIC NOTE: The Hydrophilinae of Delaware (Coleoptera: Hydrophilidae). *The Coleopterists Bulletin*, *58*(4), 598-599.

Shriver, G., C. Elphick, B. Olsen, T. Hodgman, and R. Kern. 2014. The Conservation of Tidal Marsh Birds: Guiding action at the intersection of our changing land and seascapes. Delaware Wetlands Conference, January 30, 2014, Dover, DE.

Spotila, J.R., P. Plotkin, and J. Keinath. 2007. Delaware Bay is an important foraging habitat for loggerhead turtles. Presentation #58 . The 2007 Delaware Estuary Science Conference & Environmental Summit Cape May, New Jersey, January 22 – 24, 2007.

Stein B.A., L.S. Kutner and J.S. Adams, eds. 2000.Precious Heritage: The Status of Biodiversity in the United States. NewYork: Oxford University Press

Steiner, W. E., Staines, C. L., McCann, J. M., & Hellman, J. L. (2003). The Seth Forest water scavenger beetle, a new species of Hydrochus (Coleoptera: Hydrophiloidea: Hydrochidae) from the Chesapeake-Delmarva Region. *The Coleopterists Bulletin*, *57*(4), 433-443.

Stetzar, E. 2000. *Marine mammal and sea turtle strandings in Delaware, 1962-1998*. Department of Natural Resources and Environmental Control, Division of Fish and Wildlife. Dover, DE.

Stetzar, E. 2002. *Population characterization of sea turtles that seasonally inhabit the Delaware Estuary*. Masters Thesis. Delaware State University. Dover, DE.

Stetzar, E. 2004. *Investigation of sea turtle mortality factors in Delaware waters*. Department of Natural Resources and Environmental Control, Natural Heritage and Endangered Species Program. Dover, DE.

Strayer, D. L and K. J. Jirka. 1997. *The Pearly Mussels of New York State*. New York State Museum Memoir 26. The New York State Education Department. Albany, NY.

Summerville, K.S. 2004. Functional groups and species replacement: testing for the effects of habitat loss on moth communities. *Journal of the Lepidopterists' Society* 58(2): 114-117.

Summerville, K. S. and T. O. Crist. 2002. Effects of timber harvest on forest Lepidoptera: community, guild, and species responses. *Ecological Applications* 12:820-835.

Summerville, K. S. and T. O. Crist. 2003. Determinants of lepidopteran community composition and species diversity in eastern deciduous forests: roles of season, ecoregion, and patch size. *Oikos* 100:134-148.

Teter, S. M., Wetherbee, B. M., Fox, D. A., Lam, C. H., Kiefer, D. A., & Shivji, M. (2015). Migratory patterns and habitat use of the sand tiger shark (Carcharias taurus) in the western North Atlantic.*Marine and Freshwater Research*, *66*(2), 158-169.

The H. John Heinz III Center for Science, Economics and the Environment (The Heinz Center). 2002. State of the nation's ecosystems. Cambridge University Press, Cambridge, UK.

The Heinz Center. 2008. State of the nation's ecosystems. Cambridge University Press, Cambridge, UK.

The Heinz Center. 2013. Pollinators and the State Wildlife Action Plans Voluntary Guidance for State Wildlife Agencies. Washington, DC, 20 pp

Timberdoodle. The Woodcock Management Plan. Available online at: *http://timberdoodle.org/sites/default/files/woodcockPlan_0.pdf.*

Tiner, R.W., M.A. Biddle, A.D. Jacobs, A.B. Rogerson and K.G. McGuckin. 2011. *Delaware Wetlands: Status and Changes from 1992 to 2007.* Cooperative National Wetlands Inventory Publication. U.S. Fish and Wildlife Service, Northeast Region, Hadley, MA and the Delaware Department of Natural Resources and Environmental Control, Dover, DE. 35 pp.

The Nature Conservancy (TNC). 1996. Priorities for conservation: 1996 annual report card for U.S. plant and animal species. The Nature Conservancy, Arlington, Virginia.

U.S. Environmental Protection Agency (U.S. EPA, EPA). 2002. Index of Watershed Indicators. *http://yosemite.epa.gov/water/owrccatalog.nsf/065ca07e299b464685256ce50075c11a/74cc02b7259763078525 6b0600723d41!OpenDocument*

USFWS. n.d. *Aquatic representative species selected at southern New England workshop for the North Atlantic Landscape Conservation Cooperative*. http://www.fws.gov/northeast/science/pdf/nalcc_aquatic_rep_species_table.pdf

U.S. Fish and Wildlife Service. 1994. Northeastern Beach Tiger Beetle (*Cicindela dorsalis dorsalis* Say) Recovery Plan. Hadley, Massachusetts. 60 pp. http://ecos.fws.gov/docs/recovery_plan/940929b.pdf

United States Fish and Wildlife Service (USFWS). 1996. Piping Plover (*Charadrius melodus*) Revised Recovery Plan. Prepared by the Atlantic Coast Piping Plover Recovery Team. 15 pp.

USFWS. 1998. Roseate Tern (*Sterna dougallii*) Northeast Population Recovery Plan. Prepared by the Northeast Roseate Tern Recovery Team 75 pp. *http://ecos.fws.gov/docs/recovery_plan/981105.pdf*

United States Fish and Wildlife Service (USFWS). 2003. Delaware Bay Shorebird-Horseshoe Crab Assessment: Conclusions and Recommendations to the Horseshoe Crab Management Board of the ASMFC. May, 2003, 12 pp.

United States Fish and Wildlife Service (USFWS). 2003. Delaware Bay Shorebird-Horseshoe Crab Assessment Report and Peer Review. Arlington, VA. 107pp.

USFWS. 2011. *2011 National Survey of Fishing, Hunting, and Wildlife Associated Recreation*. 143 pp.

USFWS. 2014. *Rufa* Red Knot (*Calidris canutus rufa*) listing http://www.fws.gov/northeast/redknot/

U.S. Fish and Wildlife Service. 2014. Draft technical guidance on selecting species for landscape-scale conservation. March 14, 2014. 88 pp. http://www.fws.gov/science/pdf/Draft-Technical-Guidance-on-Selecting-Species-for-Landscape-Scale-Conservation.pdf

USFWS, Region 6 Office. 2014. Final summary report: Peer review of technical guidance on selecting species for landscape scale conservation. 18 pp. http://www.fws.gov/science/pdf/Final-Summary-Report-Complete-Technical-Guidance-on-Selecting-Species-for-Landscape-Scale-Conservation.pdf

U.S. Fish and Wildlife Service. 2014. Waterfowl population status, 2014. U.S. Department of the Interior, Washington, D.C. USA. http://www.fws.gov/migratorybirds/Newreportspublications/PopulationStatus/Waterfowl/StatusReport2014.pdf

U.S. Fish and Wildlife Service. 2015. Threatened Species Status for the Northern Long-Eared Bat With 4(d) Rule. 80 FR 17973 18033.

U.S. Fish and Wildlife Service. 1993. Delmarva Fox Squirrel (*Sciurus niger cinereus*) Recovery Plan, Second Revision. Hadley, Massachusetts. 104 pp. http://ecos.fws.gov/docs/recovery_plan/930608.pdf

U.S. Fish and Wildlife Service. 2001. Bog Turtle (*Clemmys muhlenbergii*), Northern Population, Recovery Plan. Hadley, Massachusetts. 103 pp http://www.fws.gov/northeast/nyfo/es/bogturtle.pdf

U.S. Fish and Wildlife Service. 2007. *The Delmarva Peninsula Fox Squirrel (*Sciurus niger cinereus*): 5-year Status Review.* Chesapeake Bay Field Office, 177 Admiral Cochrane Dr., Annapolis, MD 21401 52 pp. www.fws.gov/chesapeakebay/EndSppWeb/DFS/StatusReview.html

U.S. Fish and Wildlife Service. 2012. *The Delmarva Peninsula Fox Squirrel* (Sciurus niger cinereus*): 5-year Status Review: Summary and Evaluation*. Chesapeake Bay Field Office. Annapolis, Maryland. 102 pp.

USFWS. 2012. *Terrestrial and Wetland Representative Species of the North Atlantic: Species Selected, Considered, and Associated Habitats (Ecological Systems)*. http://www.fws.gov/northeast/science/pdf/NALCC_Representative_Species_List_8_16_12.pdf

USFWS 2012. *Final Listing Rule for Gulf of Maine, New York Bight, and Chesapeake Bay Distinct Population Segments of Atlantic Sturgeon in the Northeast Region*. 77 FR 5880. Feb. 6, 2012.

U.S. Fish and Wildlife Service. 2014. *Draft Postdelisting Monitoring Plan for the Delmarva Peninsula fox squirrel (Sciurus niger cinereus)*. Annapolis, Maryland. 26 pp. plus Appendices.

U.S. Geological Survey. 1995. Status and trends of the nation's biological resources. U.S. Geological Survey, Washington, D.C. Available online at *http://biology.usgs.gov/s+t/SNT/index.htm*

US Shorebird Plan, 2nd Edition

Vickery, P. D. and P. W. Dunwiddie (eds.). 1997. Grasslands of Northeastern North America: ecology and conservation of native and agricultural landscapes. Massachusetts Audubon Society, Lincoln, MA.

Wagner, D. L., D. F. Schweitzer, J. B. Sullivan, and R. C. Reardon. 2011. Owlet Caterpillars of Eastern North America (Lepidoptera: Noctuidae). Princeton University Press. 576 pp.

Wallace, J.B., and N. H. Anderson. 1996. Habitat, life history, and behavioral adaptations of aquatic insects. Chapter 5, pp. 41-73, in R.W. Merritt and K. W. Cummins (editors*). An Introduction to the Aquatic Insects of North America*. 3rd edition. Kendall/Hunt, Dubuque,Iowa.

Walsh, S.J., H.L. Jelks, and N.M. Burkehead. 2009. The decline of North American Freshwater Fishes. Action Bioscience June 2009. Available online at: *http://www.actionbioscience.org/biodiversity/walsh.html.*Accessed April 8, 2014.

Wang, J.C.S., and R.J. Kernehan. 1979. *Fishes of the Delaware Estuaries a guide to the early life histories*. Ecological Analysts, Inc., Towson, MD, 410 p.

Watson, J.K. 2014. The Piedmont Bird Conservation Region (BCR 29) Implementation Plan. Version 1.1. 136 pp. http://acjv.org/documents/piedmont-2014.pdf

Weber, T.C. (2007) Development and application of a statewide conservation network in Delaware, U.S.A. *Journal of Conservation Planning* 3: 17-46.

Weir, L. A., Royle, J. A., Gazenski, K. D., & Villena, O. (2014). Northeast regional and state trends in anuran occupancy from calling survey data (2001-2011) from the North American Amphibian Monitoring Program. *Herpetological Conservation and Biology* 9: 223-245.

Wethington, A. R., Wise, J., & Dillon Jr, R. T. 2009. Genetic and morphological characterization of the Physidae of South Carolina (Gastropoda: Pulmonata: Basommatophora), with description of a new species. *Nautilus*, *123*(4), 282-292.

Wetlands International (2015). *Waterbird Population Estimates*. Retrieved from wpe.wetlands.org on 8 Apr 2015.

White, E.L., P.D. Hunt, M.D. Schlesinger, J.D. Corser, and P.G. deMaynadier. 2014. *A conservation status assessment of Odonata for the northeastern United States*. New York Natural Heritage Program, Albany, NY.

White, H.B. 2011. *Natural history of Delmarva dragonflies and damselflies: essays of a lifelong observer*. University of Delaware Press and Delaware Nature Society. 284 pp.

White, J.F., Jr. and A.W. White. 2007. *Amphibians and Reptiles of Delmarva*. 2nd edition. Centreville, MD: Tidewater Publishers. 243 pp.

Whitlock, A. 2006. Northeast States' Wildlife Action Plans (NES WAPs) Comprehensive List of Species of Greatest Conservation Need (SGCN). Unpublished Report for the Northeast Wildlife Diversity Technical Committee of the Northeastern Association of Fish and Wildlife Agencies.

Williams, J.D., M.L. Warren, Jr., K.S. Cummings, J.L. Harris, and R.J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18(9): 9-22.

Wilson, M.A. and S.R. Carpenter. 1999. Economic Valuation of Freshwater Ecosystem Services in the United States. Ecological Applications 9(3): 772-783

World Bank. 1995. The World Bank develops new system to measure wealth of nations. Press release. September 17, 1995. World Bank. Washington, D.C

Xerces Society for Invertebrate Conservation (Xerces Society). 2014. Red List of Bees: Native Bees in Decline. *http://www.xerces.org/pollinator-redlist/*

Zappalorti R. T. 1995. Marsh turtles. Pages 311-319 in L.W. Dove and R.M. Nyman, eds. Living Resources of the Delaware Estuary. The Delaware Estuary Program.